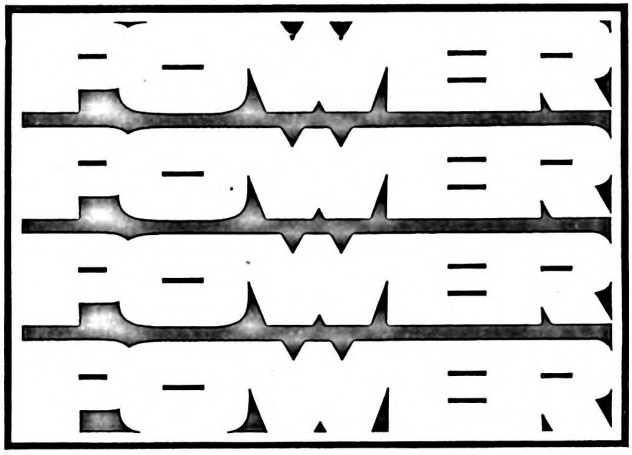
FAIRCHILD

POWER DATA BOOK

POWER DATA BOOK



FAIRCHILD

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INTRODUCTION

You, the customer, and your needs have dictated the format and contents of this Power Handbook. To be responsive to the changing requirements of the power market, Fairchild will commit resources to maintain a leading position in technology, quality, commitment to delivery schedule and service to customers.

Fairchild has long been a major supplier of bipolar power transistors. However, the thousands of EIA registered and house-numbered devices makes it impossible to second source or even cross reference all of the industry devices. This book contains popular industry preferred numbers. If a device you are using or intend to use is not contained in this handbook, please contact the factory through your local sales office or representative for Fairchild information on your requirement. The Company's broad technology base enables the manufacturing of devices to most industry numbers.

This book has been sectioned for your convenience—quick reference charts, technical information and complete data sheets—and organized as follows:

Selection Guides
Quick reference guides for designers seeking devices to meet their needs. These selection guides are arranged in several ways to make location of information easy. They also contain basic parameter information for each device plus the page number where the complete data sheet can be located.

Industry Cross Reference
Industry type number vs Fairchild's nearest equivalent, an aid to locating replacement parts for old designs.

Chapters 1 through 5
Technical information to aid the designer in selecting the correct device for his application—Technology, Safe Operating Area, Manufacturing, Packaging and Heat Sinking, and Reliability.

Product Information
Fairchild devices arranged numerically and containing electrical characteristics, SOA and electrical characteristic curves on each device. Information on processing and ordering of Fairchild power dice.

Standard Definitions of Symbols and Terms used in Specifying Power Devices

Addresses of Fairchild Sales Offices, Representatives and Distributors

As well as supplying a full line of standard devices, Fairchild has the capability of supplying custom devices tailored to your application. A complete service organization is available to assist you—a sales force consisting of sales engineers, representatives and distributors, field application engineers to help you with circuit design or device application, and customer service coordinators to resolve and expedite your order. Our goal is to give you cost-effective power transistors, timely delivery and excellent service while maintaining a top position in this field of expanding technology.

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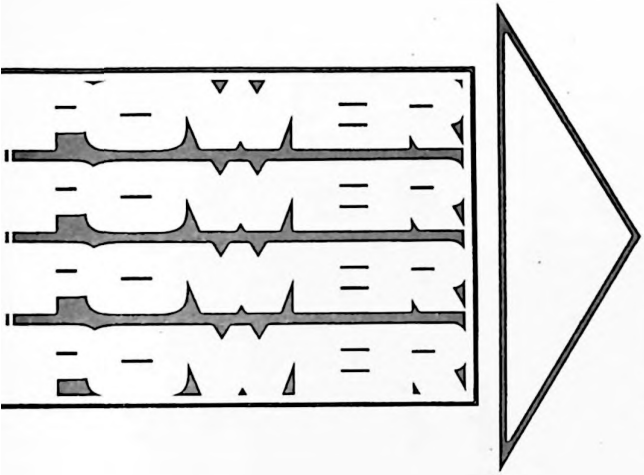

DEVICE SELECTION GUIDES AND CROSS REFERENCE

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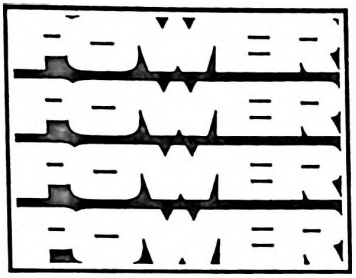

DEVICE SELECTION GUIDES AND CROSS REFERENCE

- Device Selection Guide
  Arranged by Device
- Selection Guide by $I_{C(max)}$
  Arranged by Polarity and Ascending V_{CEO}
- Selection Guide by Package
  Arranged by $I_{C(max)}$, Polarity and V_{CEO}
- Darlington Selection Guide
  Arranged by $I_{C(max)}$, Polarity and V_{CEO}
- Industry Cross Reference

SELECTION GUIDE BY DEVICE NUMBER

DEVICE	POLARITY	I_C Max A	V_{CEO} Max V	h_{FE} Min/Max @ I_C	A	$V_{CE(sat)}$ Max @ I_C V	A	f_T Min MHz	$P_{D(Max)}$ T_C=25°C W	PACK-AGE	DATA SHEET PAGE NO.
2N3054	NPN	4.0	55	25/150	0.5	1.0	0.5	-	25	TO-66	6-3
2N3055	NPN	15	60	20/70	4.0	1.1	4.0	-	117	TO-3	6-6
2N3055SD	NPN	15	60	20/70	4.0	1.1	4.0	0.8	115	TO-3	6-8
2N3439	NPN	1.0	350	40/160	0.02	0.5	0.05	15	10	TO-39	6-10
2N3440	NPN	1.0	250	40/160	0.02	0.5	0.05	15	10	TO-39	6-10
2N3713	NPN	10	60	25/75	1.0	1.0	5.0	4.0	150	TO-3	6-13
2N3714	NPN	10	80	25/75	1.0	1.0	5.0	4.0	150	TO-3	6-13
2N3715	NPN	10	60	50/150	1.0	0.8	5.0	4.0	150	TO-3	6-13
2N3716	NPN	10	80	50/150	1.0	0.8	5.0	2.5	150	TO-3	6-13
2N3740	PNP	1.0	60	30/100	0.25	0.6	1.0	4.0	25	TO-66	6-16
2N3741	PNP	1.0	80	30/100	0.25	0.6	1.0	4.0	25	TO-66	6-16
2N3766	NPN	3.0	60	40/160	0.5	1.0	0.5	10	20	TO-66	6-19
2N3767	NPN	3.0	80	40/160	0.5	1.0	0.5	10	20	TO-66	6-19
2N3771	NPN	30	40	15/60	15	2.0	15	0.2	150	TO-3	6-22
2N3772	NPN	20	60	15/60	10	1.4	10	0.2	150	TO-3	6-22
2N3789	PNP	10	60	25/90	1.0	1.0	5.0	4.0	150	TO-3	6-25
2N3790	PNP	10	80	25/90	1.0	1.0	5.0	4.0	150	TO-3	6-25
2N3791	PNP	10	60	50/180	1.0	1.0	5.0	4.0	150	TO-3	6-25
2N3792	PNP	10	80	50/180	1.0	1.0	5.0	4.0	150	TO-3	6-25
2N4231	NPN	4.0	40	25/100	1.5	0.7	1.5	4.0	35	TO-66	6-28
2N4232	NPN	4.0	60	25/100	1.5	0.7	1.5	4.0	35	TO-66	6-28
2N4233	NPN	4.0	80	25/100	1.5	0.7	1.5	4.0	35	TO-66	6-28
2N4234	PNP	3.0	40	30/150	0.25	0.6	1.0	3.0	6.0	TO-39	6-31
2N4235	PNP	3.0	60	30/150	0.25	0.6	1.0	3.0	6.0	TO-39	6-31
2N4236	PNP	3.0	80	30/150	0.25	0.6	1.0	3.0	6.0	TO-39	6-31
2N4237	NPN	4.0	40	30/150	0.25	0.6	1.0	1.0	6.0	TO-39	6-34
2N4238	NPN	4.0	60	30/150	0.25	0.6	1.0	1.0	6.0	TO-39	6-34
2N4239	NPN	4.0	80	30/150	0.25	0.6	1.0	1.0	6.0	TO-39	6-34
2N4398	PNP	30	40	15/60	15	1.0	15	4.0	200	TO-3	6-37
2N4399	PNP	30	60	15/60	15	1.0	15	4.0	200	TO-3	6-37
2N4895	NPN	5.0	60	40/120	2.0	1.0	5.0	50	7.0	TO-39	6-40
2N4896	NPN	5.0	60	100/300	2.0	1.0	5.0	80	7.0	TO-39	6-40
2N4897	NPN	5.0	80	40/120	2.0	1.0	5.0	50	7.0	TO-39	6-40
2N4898	PNP	1.0	40	20/100	0.5	0.6	1.0	3.0	25	TO-66	6-43
2N4899	PNP	1.0	60	20/100	0.5	0.6	1.0	3.0	25	TO-66	6-43
2N4900	PNP	1.0	80	20/100	0.5	0.6	1.0	3.0	25	TO-66	6-43
2N4901	PNP	5.0	40	20/80	1.0	1.5	5.0	4.0	87.5	TO-3	6-46
2N4902	PNP	5.0	60	20/80	1.0	1.5	5.0	4.0	87.5	TO-3	6-46
2N4903	PNP	5.0	80	20/80	1.0	1.5	5.0	4.0	87.5	TO-3	6-46
2N4904	PNP	5.0	40	25/100	2.5	1.5	5.0	4.0	87.5	TO-3	6-49
2N4905	PNP	5.0	60	25/100	2.5	1.5	5.0	4.0	87.5	TO-3	6-49
2N4906	PNP	5.0	80	25/100	2.5	1.5	5.0	4.0	87.5	TO-3	6-49
2N4907	PNP	10	40	20/80	4.0	0.75	4.0	4.0	150	TO-3	6-52
2N4908	PNP	10	60	20/80	4.0	0.75	4.0	4.0	150	TO-3	6-52
2N4909	PNP	10	80	20/80	4.0	2.0	10	4.0	150	TO-3	6-52
2N4910	NPN	1.0	40	20/100	0.5	0.6	1.0	4.0	25	TO-66	6-54
2N4911	NPN	1.0	60	20/100	0.5	0.6	1.0	4.0	25	TO-66	6-54
2N4912	NPN	1.0	80	20/100	0.5	0.6	1.0	4.0	25	TO-66	6-54
2N4913	NPN	5.0	40	25/100	2.5	1.5	5.0	4.0	87.5	TO-3	6-57
2N4914	NPN	5.0	60	25/100	2.5	1.5	5.0	4.0	87.5	TO-3	6-57

SELECTION GUIDE BY DEVICE NUMBER

DEVICE	POLARITY	I_C Max A	V_{CEO} Max V	h_{FE} Min/Max @ I_C	A	$V_{CE(sat)}$ Max @ I_C V	A	f_T Min MHz	$P_{D(Max)}$ T_C=25°C W	PACK-AGE	DATA SHEET PAGE NO.
2N4915	NPN	5.0	80	25/100	2.5	1.5	5.0	4.0	87.5	TO-3	6-57
2N5038	NPN	20	90	20/100	12	1.0	12	60	140	TO-3	6-60
2N5039	NPN	20	75	20/100	10	1.0	10	60	140	TO-3	6-60
2N5058	NPN	0.15	300	35/150	.03	1.0	.03	30	1.0	TO-39	6-63
2N5059	NPN	0.15	250	30/150	.03	1.0	.03	30	1.0	TO-39	6-63
2N5067	NPN	5.0	40	20/80	1.0	0.4	1.0	4.0	87.5	TO-3	6-66
2N5068	NPN	5.0	60	20/80	1.0	0.4	1.0	4.0	87.5	TO-3	6-66
2N5069	NPN	5.0	80	20/80	1.0	0.4	1.0	4.0	87.5	TO-3	6-66
2N5301	NPN	30	40	15/60	15	2.0	20	2.0	200	TO-3	6-69
2N5302	NPN	30	60	15/60	15	2.0	20	2.0	200	TO-3	6-69
2N5303	NPN	20	80	15/60	10	2.0	20	2.0	200	TO-3	6-69
2N5320	NPN	2.0	75	30/130	0.5	0.5	0.5	50	10	TO-39	6-72
2N5321	NPN	2.0	50	40/250	0.5	0.8	0.5	50	10	TO-39	6-72
2N5322	PNP	2.0	75	30/130	0.5	0.5	0.5	50	10	TO-39	6-75
2N5323	PNP	2.0	50	40/250	0.5	0.8	0.5	50	10	TO-39	6-75
2N5334	NPN	3.0	60	30/150	1.0	0.7	2.0	40	6.0	TO-39	6-78
2N5335	NPN	3.0	80	30/150	1.0	0.7	2.0	40	6.0	TO-39	6-78
2N5336	NPN	5.0	80	30/120	2.0	0.7	2.0	30	6.0	TO-39	6-81
2N5337	NPN	5.0	80	60/240	2.0	0.7	2.0	30	6.0	TO-39	6-81
2N5338	NPN	5.0	100	30/120	2.0	0.7	2.0	30	6.0	TO-39	6-84
2N5339	NPN	5.0	100	60/240	2.0	0.7	2.0	30	6.0	TO-39	6-84
2N5415	PNP	1.0	200	30/150	0.05	2.5	0.05	15	10	TO-39	6-87
2N5416	PNP	1.0	300	30/120	0.05	2.0	0.05	15	10	TO-39	6-87
2N5629	NPN	16	100	25/100	8.0	1.0	10	0.5	200	TO-3	6-90
2N5630	NPN	16	120	20/80	8.0	1.0	10	0.5	200	TO-3	6-90
2N5631	NPN	16	140	15/60	8.0	1.0	10	0.5	200	TO-3	6-90
2N5679	PNP	1.0	100	40/150	0.25	1.0	0.5	30	10	TO-39	6-92
2N5680	PNP	1.0	120	40/150	0.25	1.0	0.5	30	10	TO-39	6-92
2N5681	NPN	1.0	100	40/150	0.25	1.0	0.5	30	10	TO-39	6-95
2N5682	NPN	1.0	120	40/150	0.25	1.0	0.5	30	10	TO-39	6-95
2N5683	PNP	50	60	15/60	25	1.0	25	2.0	300	TO-3	6-98
2N5684	PNP	50	80	15/60	25	1.0	25	2.0	300	TO-3	6-98
2N5685	NPN	50	60	15/60	25	1.0	25	2.0	300	TO-3	6-101
2N5686	NPN	50	80	15/60	25	1.0	25	2.0	300	TO-3	6-101
2N5838	NPN	3.0	250	8/40	3.0	1.0	3.0	5.0	100	TO-3	6-105
2N5839	NPN	3.0	275	10/50	2.0	1.5	2.0	5.0	100	TO-3	6-105
2N5840	NPN	3.0	350	10/50	2.0	1.5	2.0	5.0	100	TO-3	6-105
2N5871	PNP	7.0	60	20/100	2.5	1.0	4.0	4.0	115	TO-3	6-108
2N5872	PNP	7.0	80	20/100	2.5	1.0	4.0	4.0	115	TO-3	6-108
2N5873	NPN	7.0	60	20/100	2.5	1.0	4.0	4.0	115	TO-3	6-111
2N5874	NPN	7.0	80	20/100	2.5	1.0	4.0	4.0	115	TO-3	6-111
2N5875	PNP	8.0	60	20/100	4.0	1.0	5.0	4.0	150	TO-3	6-114
2N5876	PNP	8.0	80	20/100	4.0	1.0	5.0	4.0	150	TO-3	6-114
2N5877	NPN	8.0	60	20/100	4.0	1.0	5.0	4.0	150	TO-3	6-117
2N5878	NPN	8.0	80	20/100	4.0	1.0	5.0	4.0	150	TO-3	6-117
2N5879	PNP	12	60	20/100	6.0	1.0	7.0	4.0	160	TO-3	6-120
2N5880	PNP	12	80	20/100	6.0	1.0	7.0	4.0	160	TO-3	6-120
2N5881	NPN	12	60	20/100	6.0	1.0	7.0	4.0	160	TO-3	6-123
2N5882	NPN	12	80	20/100	6.0	1.0	7.0	4.0	160	TO-3	6-123
2N5883	PNP	20	60	20/100	10	1.0	15	4.0	200	TO-3	6-126

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DEVICE	POLARITY	I_C Max A	V_{CEO} Max V	h_{FE} Min/Max @ I_C A		$V_{CE(sat)}$ Max @ I_C V	A	f_T Min MHz	$P_{D(Max)}$ T_C=25°C W	PACK-AGE	DATA SHEET PAGE NO.
2N5884	PNP	20	80	20/100	10	1.0	15	4.0	200	TO-3	6-126
2N5885	NPN	20	60	20/100	10	1.0	15	4.0	200	TO-3	6-129
2N5886	NPN	20	80	20/100	10	1.0	15	4.0	200	TO-3	6-129
2N6029	PNP	16	100	25/100	8.0	2.0	16	1.0	200	TO-3	6-132
2N6030	PNP	16	120	20/80	8.0	2.0	16	1.0	200	TO-3	6-132
2N6031	PNP	16	140	15/60	8.0	2.0	16	1.0	200	TO-3	6-132
2N6050	PNP	12	60	750/18K	6.0	2.0	6.0	4.0	150	TO-3	6-134
2N6051	PNP	12	80	750/18K	6.0	2.0	6.0	4.0	150	TO-3	6-134
2N6052	PNP	12	100	750/18K	6.0	2.0	6.0	4.0	150	TO-3	6-134
2N6053	PNP	8.0	60	750/18K	4.0	2.0	4.0	4.0	100	TO-3	6-137
2N6054	PNP	8.0	80	750/18K	4.0	2.0	4.0	4.0	100	TO-3	6-137
2N6055	NPN	8.0	60	750/18K	4.0	2.0	4.0	4.0	100	TO-3	6-140
2N6056	NPN	8.0	80	750/18K	4.0	2.0	4.0	4.0	100	TO-3	6-140
2N6057	NPN	12	60	750/18K	6.0	2.0	6.0	4.0	150	TO-3	6-143
2N6058	NPN	12	80	750/18K	6.0	2.0	6.0	4.0	150	TO-3	6-143
2N6059	NPN	12	100	750/18K	6.0	2.0	6.0	4.0	150	TO-3	6-143
2N6121	NPN	4.0	45	25/100	1.5	0.6	1.5	2.5	40	TO-220	6-146
2N6122	NPN	4.0	60	25/100	1.5	0.6	1.5	2.5	40	TO-220	6-146
2N6123	NPN	4.0	80	20/80	1.5	0.6	1.5	2.5	40	TO-220	6-146
2N6124	PNP	4.0	45	25/100	1.5	0.6	1.5	2.5	40	TO-220	6-149
2N6125	PNP	4.0	60	25/100	1.5	0.6	1.5	2.5	40	TO-220	6-149
2N6126	PNP	4.0	80	20/80	1.5	0.6	1.5	2.5	40	TO-220	6-149
2N6129	NPN	7.0	40	20/100	2.5	1.4	7.0	2.5	50	TO-220	6-152
2N6130	NPN	7.0	60	20/100	2.5	1.4	7.0	2.5	50	TO-220	6-152
2N6131	NPN	7.0	80	20/100	2.5	2.0	7.0	2.5	50	TO-220	6-152
2N6132	PNP	7.0	40	20/100	2.5	1.4	7.0	2.5	50	TO-220	6-155
2N6133	PNP	7.0	60	20/100	2.5	1.4	7.0	2.5	50	TO-220	6-155
2N6134	PNP	7.0	80	20/100	2.5	2.0	7.0	2.5	50	TO-220	6-155
2N6249	NPN	10	200	10/50	10	1.5	10	2.5	100	TO-3	6-158
2N6250	NPN	10	275	8/50	10	1.5	10	2.5	100	TO-3	6-158
2N6251	NPN	10	350	6/50	10	1.5	10	2.5	100	TO-3	6-158
2N6282	NPN	20	60	750/18K	10	2.0	10	4.0	160	TO-3	6-161
2N6283	NPN	20	80	750/18K	10	2.0	10	4.0	160	TO-3	6-161
2N6284	NPN	20	100	750/18K	10	2.0	10	4.0	160	TO-3	6-161
2N6285	PNP	20	60	750/18K	10	2.0	10	4.0	160	TO-3	6-164
2N6286	PNP	20	80	750/18K	10	2.0	10	4.0	160	TO-3	6-164
2N6287	PNP	20	100	750/18K	10	2.0	10	4.0	160	TO-3	6-164
2N6306	NPN	8.0	250	15/75	3.0	0.8	3.0	5.0	125	TO-3	6-167
2N6307M	NPN	8.0	300	15/75	3.0	1.0	3.0	5.0	125	TO-3	6-167
2N6308M	NPN	8.0	350	12/60	3.0	1.5	3.0	5.0	125	TO-3	6-167
2N6383	NPN	10	40	1K/20K	5.0	2.0	5.0	20	100	TO-3	6-170
2N6384	NPN	10	60	1K/20K	5.0	2.0	5.0	20	100	TO-3	6-170
2N6385	NPN	10	80	1K/20K	5.0	2.0	5.0	20	100	TO-3	6-170
2N6386	NPN	10	40	1K/20K	3.0	2.0	3.0	20	40	TO-220	6-173
2N6387	NPN	10	60	1K/20K	3.0	2.0	3.0	20	40	TO-220	6-173
2N6388	NPN	10	80	1K/20K	3.0	2.0	3.0	20	40	TO-220	6-173
2N6473	NPN	4.0	100	15/150	1.5	1.2	1.5	10	40	TO-220	6-176
2N6474	NPN	4.0	120	15/150	1.5	1.2	1.5	10	40	TO-220	6-176
2N6475	PNP	4.0	100	15/150	1.5	1.2	1.5	10	40	TO-220	6-178
2N6476	PNP	4.0	120	15/150	1.5	1.2	1.5	10	40	TO-220	6-178
2N6486	NPN	15	40	20/150	5.0	1.3	5.0	5.0	75	TO-220	6-180

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DEVICE	POLARITY	I_C Max A	V_{CEO} Max V	h_{FE} Min/Max @ I_C A		$V_{CE(sat)}$ Max @ I_C V	A	f_T Min MHz	$P_{D(Max)}$ T_C=25°C W	PACK-AGE	DATA SHEET PAGE NO
2N6487	NPN	15	60	20/150	5.0	1.3	5.0	5.0	75	TO-220	6-180
2N6488	NPN	15	80	20/150	5.0	1.3	5.0	5.0	75	TO-220	6-180
2N6489	PNP	15	40	20/150	5.0	1.3	5.0	5.0	75	TO-220	6-182
2N6490	PNP	15	60	20/150	5.0	1.3	5.0	5.0	75	TO-220	6-182
2N6491	PNP	15	80	20/150	5.0	1.3	5.0	5.0	75	TO-220	6-182
2N6569	NPN	12	40	15/200	4.0	1.5	4.0	1.5	100	TO-3	6-184
2N6576	NPN	15	60	2K/20K	4.0	4.0	15	10	120	TO-3	6-186
2N6577	NPN	15	90	2K/20K	4.0	4.0	15	10	120	TO-3	6-186
BC323	NPN	5.0	60	50/250	0.5	0.15	0.5	-	7.0	TO-39	6-189
BD220	NPN	4.0	70	30/120	0.5	1.0	0.5	0.8	36	TO-220	6-191
BD221	NPN	4.0	40	30/120	1.0	1.0	1.0	0.8	36	TO-220	6-191
BD222	NPN	4.0	60	20/80	1.5	1.0	1.5	0.8	36	TO-220	6-191
BD223	PNP	4.0	70	30/120	0.5	1.0	0.5	0.8	36	TO-220	6-194
BD224	PNP	4.0	40	30/120	1.0	1.0	1.0	0.8	36	TO-220	6-194
BD225	PNP	4.0	60	20/80	1.5	1.0	1.5	0.8	36	TO-220	6-194
BFX34	NPN	5.0	60	40/150	2.0	1.0	5.0	70	5.0	TO-39	6-197
BF257	NPN	0.1	160	25/-	0.03	1.0	0.03	75*	1.0	TO-39	6-200
BF258	NPN	0.1	250	25/-	0.03	1.0	0.03	75*	1.0	TO-39	6-200
BF259	NPN	0.1	300	25/-	0.03	1.0	0.03	75*	1.0	TO-39	6-200
BF336	NPN	0.1	180	20/-	0.03	-	-	50	1.0	TO-39	6-202
BF337	NPN	0.1	200	20/-	0.03	-	-	50	1.0	TO-39	6-202
BF338	NPN	0.1	225	20/-	0.03	-	-	50	1.0	TO-39	6-202
FT47	NPN	1.0	250	30/150	0.3	1.0	1.0	10	40	TO-220	6-204
FT48	NPN	1.0	300	30/150	0.3	1.0	1.0	10	40	TO-220	6-204
FT49	NPN	1.0	350	30/150	0.3	1.0	1.0	10	40	TO-220	6-204
FT50	NPN	1.0	400	30/150	0.3	1.0	1.0	10	40	TO-220	6-204
FT317	NPN	4.0	100	35/-	1.0	0.5	1.0	20	40	TO-220	6-206
FT317A	NPN	4.0	120	35/-	1.0	0.5	1.0	20	40	TO-220	6-206
FT317B	NPN	4.0	140	35/-	1.0	0.5	1.0	20	40	TO-220	6-206
FT359	NPN	10	350	250/-	3.0	2.5	7.0	-	125	TO-3	6-208
FT401	NPN	2.0	300	20/100	0.5	0.8	0.5	2.0	100	TO-3	6-210
FT402	NPN	3.5	325	20/100	0.5	2.0	3.0	2.0	100	TO-3	6-210
FT410	NPN	7.5	200	30/90	1.0	0.8	1.0	-	100	TO-3	6-212
FT411	NPN	7.5	300	30/90	1.0	0.8	1.0	-	100	TO-3	6-212
FT413	NPN	7.5	325	20/80	0.5	0.8	0.5	-	100	TO-3	6-214
FT417	PNP	4.0	100	35/-	1.0	0.5	1.0	20	40	TO-220	6-216
FT417A	PNP	4.0	120	35/-	1.0	0.5	1.0	20	40	TO-220	6-216
FT417B	PNP	4.0	140	35/-	1.0	0.5	1.0	20	40	TO-220	6-216
FT423	NPN	7.5	325	30/90	1.0	0.8	1.0	-	100	TO-3	6-214
FT430	NPN	10	300	15/45	2.5	0.9	2.5	-	125	TO-3	6-218
FT431	NPN	10	325	15/35	2.5	0.7	2.5	-	125	TO-3	6-218
FT2955	PNP	10	60	20/70	4.0	1.1	4.0	2.0	70	TO-220	6-220
FT3055	NPN	10	60	20/70	4.0	1.1	4.0	2.0	70	TO-220	6-222
FT5415	PNP	1.0	200	30/150	0.05	-	-	15	10	TO-39	
FT5416	PNP	1.0	300	30/120	0.05	-	-	15	10	TO-39	
MJ802	NPN	30	90	25/100	7.5	0.8	7.5	2.0	200	TO-3	6-224
MJ4502	PNP	30	90	25/100	7.5	0.8	7.5	2.0	200	TO-3	6-226
MJE3055F	NPN	10	60	20/70	4.0	1.1	4.0	2.0	70	TO-220	6-228
SE7055	NPN	0.5	220	40/-	0.01	1.0	0.02	50	1.0	TO-39	6-232
SE7056	NPN	0.5	300	40/-	0.01	1.0	0.02	50	1.0	TO-39	6-232

*TYPICAL

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DEVICE	POLARITY	I_C Max A	V_{CEO} Max V	h_{FE} Min/Max @ I_C A	$V_{CE(sat)}$ Max @ I_C V	A	f_T Min MHz	$P_{D(Max)}$ T_C=25°C W	PACK-AGE	DATA SHEET PAGE NO.
SE9300	NPN	10	60	1K/- 4.0	2.0	4.0	1.0	70	TO-220	6-235
SE9301	NPN	10	80	1K/- 4.0	2.0	4.0	1.0	70	TO-220	6-235
SE9302	NPN	10	100	1K/- 4.0	2.0	4.0	1.0	70	TO-220	6-235
SE9303	NPN	10	60	1K/- 4.0	2.0	4.0	1.0	100	TO-3	6-237
SE9304	NPN	10	80	1K/- 4.0	2.0	4.0	1.0	100	TO-3	6-237
SE9305	NPN	10	100	1K/- 4.0	2.0	4.0	1.0	100	TO-3	6-237
SE9331	NPN	1.0	300	30/250 0.1	2.5	10	10	20	TO-66	6-239
SE9400	PNP	10	60	1K/- 4.0	2.0	4.0	1.0	70	TO-220	6-241
SE9401	PNP	10	80	1K/- 4.0	2.0	4.0	1.0	70	TO-220	6-241
SE9402	PNP	10	100	1K/- 4.0	2.0	4.0	1.0	70	TO-220	6-241
SE9403	PNP	10	60	1K/- 4.0	2.0	4.0	1.0	100	TO-3	6-243
SE9404	PNP	10	80	1K/- 4.0	2.0	4.0	1.0	100	TO-3	6-243
SE9405	PNP	10	100	1K/- 4.0	2.0	4.0	1.0	100	TO-3	6-243
TIP29	NPN	3.0	40	15/75 1.0	0.7	1.0	3.0	30	TO-220	6-245
TIP29A	NPN	3.0	60	15/75 1.0	0.7	1.0	3.0	30	TO-220	6-245
TIP29B	NPN	3.0	80	15/75 1.0	0.7	1.0	3.0	30	TO-220	6-245
TIP29C	NPN	3.0	100	15/75 1.0	0.7	1.0	3.0	30	TO-220	6-245
TIP30	PNP	3.0	40	15/75 1.0	0.7	1.0	3.0	30	TO-220	6-248
TIP30A	PNP	3.0	60	15/75 1.0	0.7	1.0	3.0	30	TO-220	6-248
TIP30B	PNP	3.0	80	15/75 1.0	0.7	1.0	3.0	30	TO-220	6-248
TIP30C	PNP	3.0	100	15/75 1.0	0.7	1.0	3.0	30	TO-220	6-248
TIP31	NPN	5.0	40	10/50 3.0	1.2	3.0	3.0	40	TO-220	6-251
TIP31A	NPN	5.0	60	10/50 3.0	1.2	3.0	3.0	40	TO-220	6-251
TIP31B	NPN	5.0	80	10/50 3.0	1.2	3.0	3.0	40	TO-220	6-251
TIP31C	NPN	5.0	100	10/50 3.0	1.2	3.0	3.0	40	TO-220	6-251
TIP32	PNP	5.0	40	10/50 3.0	1.2	3.0	3.0	40	TO-220	6-254
TIP32A	PNP	5.0	60	10/50 3.0	1.2	3.0	3.0	40	TO-220	6-254
TIP32B	PNP	5.0	80	10/50 3.0	1.2	3.0	3.0	40	TO-220	6-254
TIP32C	PNP	5.0	100	10/50 3.0	1.2	3.0	3.0	40	TO-220	6-254
TIP41	NPN	6.0	40	30/- 0.3	1.5	6.0	3.0	65	TO-220	6-257
TIP41A	NPN	6.0	60	30/- 0.3	1.5	6.0	3.0	65	TO-220	6-257
TIP41B	NPN	6.0	80	30/- 0.3	1.5	6.0	3.0	65	TO-220	6-257
TIP41C	NPN	6.0	100	30/- 0.3	1.5	6.0	3.0	65	TO-220	6-257
TIP42	PNP	6.0	40	30/- 0.3	1.5	6.0	3.0	65	TO-220	6-259
TIP42A	PNP	6.0	60	30/- 0.3	1.5	6.0	3.0	65	TO-220	6-259
TIP42B	PNP	6.0	80	30/- 0.3	1.5	6.0	3.0	65	TO-220	6-259
TIP42C	PNP	6.0	100	30/- 0.3	1.5	6.0	3.0	65	TO-220	6-259
TIP61	NPN	0.5	40	40/- 0.05	0.7	0.5	3.0	15	TO-220	6-261
TIP61A	NPN	0.5	60	40/- 0.05	0.7	0.5	3.0	15	TO-220	6-261
TIP61B	NPN	0.5	80	40/- 0.05	0.7	0.5	3.0	15	TO-220	6-261
TIP61C	NPN	0.5	100	40/- 0.05	0.7	0.5	3.0	15	TO-220	6-261
TIP62	PNP	0.5	40	40/- 0.05	0.7	0.5	3.0	15	TO-220	6-263
TIP62A	PNP	0.5	60	40/- 0.05	0.7	0.5	3.0	15	TO-220	6-263
TIP62B	PNP	0.5	80	40/- 0.05	0.7	0.5	3.0	15	TO-220	6-263
TIP62C	PNP	0.5	100	40/- 0.05	0.7	0.5	3.0	15	TO-220	6-263
TIP110	NPN	2.0	60	1K/- 1.0	2.5	2.0	-	50	TO-220	6-265
TIP111	NPN	2.0	80	1K/- 1.0	2.5	2.0	-	50	TO-220	6-265
TIP112	NPN	2.0	100	1K/- 1.0	2.5	2.0	-	50	TO-220	6-265
TIP115	PNP	2.0	60	1K/- 1.0	2.5	2.0	-	50	TO-220	6-267
TIP116	PNP	2.0	80	1K/- 1.0	2.5	2.0	-	50	TO-220	6-267

SELECTION GUIDE BY DEVICE NUMBER

DEVICE	POLARITY	I_C Max A	V_{CEO} Max V	h_{FE} Min/Max @ I_C A	$V_{CE(sat)}$ Max @ I_C V	A	f_T Min MHz	$P_{D(Max)}$ T_C=25°C W	PACK-AGE	DATA SHEET PAGE NO
TIP117	PNP	2.0	100	1K/- 1.0	2.5	2.0	-	50	TO-220	6-267
TIP120	NPN	5.0	60	1K/- 0.5	2.0	3.0	-	65	TO-220	6-269
TIP121	NPN	5.0	80	1K/- 0.5	2.0	3.0	-	65	TO-220	6-269
TIP122	NPN	5.0	100	1K/- 0.5	2.0	3.0	-	65	TO-220	6-269
TIP125	PNP	5.0	60	1K/- 0.5	2.0	3.0	-	65	TO-220	6-271
TIP126	PNP	5.0	80	1K/- 0.5	2.0	3.0	-	65	TO-220	6-271
TIP127	PNP	5.0	100	1K/- 0.5	2.0	3.0	-	65	TO-220	6-271

SELECTION GUIDE BY $I_{C(max)}$, POLARITY AND ASCENDING V_{CEO}

DEVICE POLARITY NPN	PNP	V_{CEO} Max V	h_{FE} Min/Max	@ I_C A	$V_{CE(sat)}$ Max	@ I_C A	f_T Min MHz	$P_{D(Max)}$ T_C = 25°C W	PACK-AGE	DATA SHEET PAGE NO
I_C = 0.1 A Max Continuous										
BF257		160	25/-	0.03	1.0	0.03	*75	1.0	TO-39	6-200
BF336		180	20/-	0.03			50	1.0	TO-39	6-202
BF337		200	20/-	0.03			50	1.0	TO-39	6-202
BF338		225	20/-	0.03			50	1.0	TO-39	6-202
BF258		250	25/-	0.03	1.0	0.03	*75	1.0	TO-39	6-200
BF259		300	25/-	0.03	1.0	0.03	*75	1.0	TO-39	6-200
I_C = 0.15 A Max Continuous										
2N5059		250	30/150	0.03	1.0	0.03	30	1.0	TO-39	6-63
2N5058		300	35/150	0.03	1.0	0.03	30	1.0	TO-39	6-63
I_C = 0.5 A Max Continuous										
TIP61	TIP62	40	40/-	0.05	0.07	0.5	3.0	15	TO-220	6-261
TIP61A	TIP62A	60	40/-	0.05	0.07	0.5	3.0	15	TO-220	6-261
TIP61B	TIP62B	80	40/-	0.05	0.07	0.5	3.0	15	TO-220	6-261
TIP61C	TIP62C	100	40/-	0.05	0.07	0.5	3.0	15	TO-220	6-261
SE7055		220	40/-	0.03	1.0	0.02	50	1.0	TO-39	6-232
SE7056		300	40/-	0.03	1.0	0.02	50	1.0	TO-39	6-232
I_C = 1.0 A Max Continuous										
	2N4898	40	20/100	0.5	0.6	1.0	3.0	25	TO-66	6-43
2N4910		40	20/100	0.5	0.6	1.0	4.0	25	TO-66	6-54
	2N3740	60	30/100	0.25	0.6	1.0	4.0	25	TO-66	6-16
2N4911		60	20/100	0.5	0.5	1.0	4.0	25	TO-66	6-54
	2N4899	60	20/100	0.5	0.6	1.0	3.0	25	TO-66	6-43
	2N3741	80	30/100	0.25	0.6	1.0	4.0	25	TO-66	6-16
	2N4900	80	20/100	0.5	0.6	1.0	3.0	25	TO-66	6-43
2N4912		80	20/100	0.5	0.6	1.0	4.0	25	TO-66	6-54
2N5681	2N5679	100	40/150	0.25	1.0	0.5	30	10	TO-39	6-95
2N5682	2N5680	120	40/150	0.25	1.0	0.5	30	10	TO-39	6-95
	2N5415	200	30/150	0.05	2.5	0.5	15	10	TO-39	6-87
2N3440		250	40/160	0.02	0.5	0.05	15	10	TO-39	6-10
FT47		250	30/150	0.3	1.0	1.0	10	40	TO-220	6-204
SE9331		300	30/250	0.1	2.5	0.1	10	20	TO-66	6-239
FT48		300	30/150	0.3	1.0	1.0	10	40	TO-220	6-204
	2N5416	300	30/120	0.05	2.0	0.05	15	10	TO-39	6-87
2N3439		350	40/160	0.02	0.5	0.05	15	10	TO-39	6-10
FT49		350	30/150	0.3	1.0	1.0	10	40	TO-220	6-204
FT50		400	30/150	0.3	1.0	1.0	10	40	TO-220	6-204
I_C = 2.0 A Max Continuous										
2N5321		50	40/250	0.5	0.8	0.5	50	10	TO-39	6-72
	2N5323	50	40/250	0.5	0.8	0.5	50	10	TO-39	6-75
TIP110	TIP115	60	1K/-	1.0	2.5	2.0		50	TO-220	6-265
2N5320	2N5322	75	30/130	0.5	0.5	0.5	50	10	TO-39	6-72,75
TIP111	TIP116	80	1K/-	1.0	2.5	2.0		50	TO-220	6-265,267
TIP112	TIP117	100	1K/-	1.0	2.5	2.0		50	TO-220	6-265,267
FT401		300	20/100	0.5	0.8	0.5	2.0	100	TO-3	6-210
I_C = 3.0 A Max Continuous										
	2N4234	40	30/150	0.25	0.6	1.0	3.0	6.0	TO-39	6-31
TIP29	TIP30	40	15/75	1.0	0.7	1.0	3.0	30	TO-220	6-245,248
	2N4235	60	30/150	0.25	0.6	1.0	3.0	6.0	TO-39	6-31
2N3766		60	40/160	0.5	1.0	0.5	10	20	TO-66	6-19

*TYPICAL VALUE

SELECTION GUIDE BY $I_{C(max)}$, POLARITY AND ASCENDING V_{CEO}

DEVICE POLARITY NPN	PNP	V_{CEO} Max V	h_{FE} Min/Max	@ I_C A	$V_{CE(sat)}$ Max	@ I_C A	f_T Min MHz	$P_{D(Max)}$ T_C = 25°C W	PACK-AGE	DATA SHEET PAGE NO
I_C = 3.0 A Max Continuous (Cont'd)										
TIP29A	TIP30A	60	15/75	1.0	0.7	1.0	3.0	30	TO-220	6-245,248
2N5334		60	30/150	1.0	0.7	2.0	40	6.0	TO-39	6-78
	2N4236	80	30/150	0.25	0.6	1.0	3.0	6.0	TO-39	6-31
2N3767		80	40/160	0.5	1.0	0.5	10	20	TO-66	6-19
TIP29B	TIP30B	80	15/75	1.0	0.7	1.0	3.0	30	TO-220	6-245,248
2N5335		80	30/150	1.0	0.7	2.0	40	6.0	TO-39	6-78
TIP29C	TIP30C	100	15/75	1.0	0.7	1.0	3.0	30	TO-220	6-245,248
2N5838		250	8/40	3.0	1.0	3.0	5.0	100	TO-3	6-105
2N5839		275	10/50	2.0	1.5	2.0	5.0	100	TO-3	6-105
FT402		325	20/100	0.5	2.0	3.0	2.0	100	TO-3	6-210
2N5840		350	10/50	2.0	1.5	2.0	5.0	100	TO-3	6-105
I_C = 4.0 A Max Continuous										
BD221	BD224	40	30/120	1.0	1.0	1.0	0.8	36	TO-220	6-191
2N4231		40	25/100	1.5	0.7	1.5	4.0	35	TO-66	6-28
2N4237		40	30/150	0.25	0.6	1.0	1.0	6.0	TO-39	6-34
2N6121	2N6124	45	25/100	1.5	0.6	1.5	2.5	40	TO-220	6-146,149
2N3054		55	25/150	0.5	1.0	0.5		25	TO-66	6-3
BD222	BD225	60	20/80	1.5	1.0	1.5	0.8	36	TO-220	6-191,194
2N6122	2N6125	60	25/100	1.5	0.6	1.5	2.5	40	TO-220	6-146,149
2N4232		60	25/100	1.5	0.7	1.5	4.0	35	TO-66	6-28
2N4238		60	30/150	0.25	0.6	1.0	1.0	6.0	TO-39	6-34
BD220	BD223	70	30/120	0.5	1.0	0.5	0.8	36	TO-220	6-191,194
2N6123	2N6126	80	20/80	1.5	0.6	1.5	2.5	40	TO-220	6-146,149
2N4233		80	25/100	1.5	0.7	1.5	4.0	35	TO-66	6-28
2N4239		80	30/150	0.25	0.6	1.0	1.0	6.0	TO-39	6-34
FT317	FT417	100	35/-	1.0	0.5	1.0	20	40	TO-220	6-206,216
2N6473	2N6475	100	15/150	1.5	1.2	1.5	10	40	TO-220	6-176,178
FT317A	FT417A	120	35/-	1.0	0.5	1.0	20	40	TO-220	6-206,216
2N6474	2N6476	120	15/150	1.5	1.2	1.5	10	40	TO-220	6-176,178
FT317B	FT417B	140	35/-	1.0	0.5	1.0	20	40	TO-220	6-206,216
I_C = 5.0 A Max Continuous										
2N5067	2N4901	40	20/80	1.0	0.4	1.0	4.0	87.5	TO-3	6-66,46
2N4913	2N4904	40	25/100	2.5	1.5	5.0	4.0	87.5	TO-3	6-57,49
TIP31	TIP32	40	10/50	3.0	1.2	3.0	3.0	40	TO-220	6-251,254
TIP120	TIP125	60	1K/-	0.5	2.0	3.0		65	TO-220	6-269,271
BC323		60	50/250	0.5	0.15	0.5		7.0	TO-39	6-189
2N5068	2N4902	60	20/80	1.0	0.4	1.0	4.0	87.5	TO-3	6-66,46
2N4895		60	40/120	2.0	1.0	5.0	50	7.0	TO-39	6-40
BFX34		60	40/150	2.0	1.0	0.5	70	5.0	TO-39	6-197
2N4896		60	100/300	2.0	1.0	5.0	80	7.0	TO-39	6-40
2N4914	2N4905	60	25/100	2.5	1.5	5.0	4.0	87.5	TO-3	6-57,49
TIP31A	TIP32A	60	10/50	3.0	1.2	3.0	3.0	40	TO-220	6-251,254
TIP121	TIP126	80	1K/-	0.5	2.0	3.0		65	TO-220	6-269,271
2N5069	2N4903	80	20/80	1.0	0.4	1.0	4.0	87.5	TO-3	6-66,46
2N4897		80	40/120	2.0	1.0	5.0	50	7.0	TO-39	6-40
2N5336		80	30/120	2.0	0.7	2.0	30	6.0	TO-39	6-81
2N5337		80	60/240	2.0	0.7	2.0	30	6.0	TO-39	6-81
2N4915	2N4906	80	25/100	2.5	1.5	5.0	4.0	87.5	TO-3	6-57,49
TIP31B	TIP32B	80	10/50	3.0	1.2	3.0	3.0	40.0	TO-220	6-251,254
TIP122	TIP127	100	1K/-	0.5	2.0	3.0		65	TO-220	6-269,271
2N5338		100	30/120	2.0	0.7	2.0	30	6.0	TO-39	6-84

*TYPICAL VALUE

SELECTION GUIDE BY $I_{C(max)}$, POLARITY AND ASCENDING V_{CEO}

DEVICE POLARITY NPN	PNP	V_{CEO} Max V	h_{FE} Min/Max	@ I_C A	$V_{CE(sat)}$ Max	@ I_C A	f_T Min MHz	$P_{D(Max)}$ $T_C = 25°C$ W	PACKAGE	DATA SHEET PAGE NO.
I_C = 5.0 A Max Continuous (Cont'd)										
2N5339		100	60/240	2.0	0.7	2.0	30	6.0	TO-39	6-84
TIP31C	TIP32C	100	10/50	3.0	1.2	3.0	3.0	40	TO-220	6-251,254
I_C = 6.0 A Max Continuous										
TIP41	TIP42	40	30/-	0.3	1.5	6.0	3.0	65	TO-220	6-257,259
TIP41A	TIP42A	60	30/-	0.3	1.5	6.0	3.0	65	TO-220	6-257,259
TIP41B	TIP42B	80	30/-	0.3	1.5	6.0	3.0	65	TO-220	6-257,259
TIP41C	TIP42C	100	30/-	0.3	1.5	6.0	3.0	65	TO-220	6-257,259
I_C = 7.0 A Max Continuous										
2N6129	2N6132	40	20/100	2.5	1.4	7.0	2.5	50	TO-220	6-152,155
2N5873	2N5871	60	20/100	2.5	1.0	4.0	4.0	115	TO-3	6-111,108
2N6130	2N6133	60	20/100	2.5	1.4	7.0	2.5	50	TO-220	6-152,155
2N5874	2N5872	80	20/100	2.5	1.0	4.0	4.0	115	TO-3	6-111,108
2N6131	2N6134	80	20/100	2.5	2.8	7.0	2.5	50	TO-220	6-152,155
I_C = 7.5 A Max Continuous										
FT410		200	30/90	1.0	0.8	1.0	*5.0	100	TO-3	6-212
FT411		300	30/90	1.0	0.8	1.0	*5.0	100	TO-3	6-212
FT413		325	20/80	0.5	0.8	0.5	*5.0	100	TO-3	6-214
FT423		325	30/90	1.0	0.8	1.0	*5.0	100	TO-3	6-214
I_C = 8.0 A Max Continuous										
2N5877	2N5875	60	20/100	4.0	1.0	5.0	4.0	150	TO-3	6-117,114
2N6055	2N6053	60	750/18K	4.0	2.0	4.0	4.0	100	TO-3	6-140,137
2N5878	2N5876	80	20/100	4.0	1.0	5.0	4.0	150	TO-3	6-117,137
2N6056	2N6054	80	750/18K	4.0	2.0	4.0	4.0	100	TO-3	6-140,137
2N6306		250	15/75	3.0	0.8	3.0	5.0	125	TO-3	6-167
2N6307M		300	15/75	3.0	1.0	3.0	5.0	125	TO-3	6-167
2N6308M		350	12/60	3.0	1.5	3.0	5.0	125	TO-3	6-167
I_C = 10.0 A Max Continuous										
2N6386		40	1K/20K	3.0	2.0	3.0	20	40	TO-220	6-173
	2N4907	40	20/80	4.0	0.75	4.0	4.0	150	TO-3	6-52
2N6383		40	1K/20K	5.0	2.0	5.0	20	100	TO-3	6-170
2N3713		60	25/75	1.0	1.0	5.0	4.0	150	TO-3	6-13
	2N3789	60	25/90	1.0	1.0	5.0	4.0	150	TO-3	6-25
2N3715		60	50/150	1.0	0.8	5.0	4.0	150	TO-3	6-13
	2N3791	60	50/180	1.0	1.0	5.0	4.0	150	TO-3	6-25
2N6387		60	1K/20K	3.0	2.0	3.0	20	40	TO-220	6-173
MJE3055F		60	20/70	4.0	1.1	4.0	2.0	70	TO-220	6-228
	2N4908	60	20/80	4.0	0.75	4.0	4.0	150	TO-3	6-52
SE9300	SE9400	60	1K/-	4.0	2.0	4.0	1.0	70	TO-220	6-235,241
SE9303	SE9403	60	1K/-	4.0	2.0	4.0	1.0	100	TO-3	6-237,243
2N6384		60	1K/20K	5.0	2.0	5.0	20	100	TO-3	6-170
2N3714		80	25/75	1.0	1.0	5.0	4.0	150	TO-3	6-13
	2N3790	80	25/90	1.0	1.0	5.0	4.0	150	TO-3	6-25
2N3716		80	50/150	1.0	0.8	5.0	4.0	150	TO-3	6-13
	2N3792	80	50/180	1.0	1.0	5.0	4.0	150	TO-3	6-25
2N6388		80	1K/20K	3.0	2.0	3.0	20	40	TO-220	6-173
	2N4909	80	20/80	4.0	0.75	4.0	4.0	150	TO-3	6-52
SE9304	SE9404	80	1K/-	4.0	2.0	4.0	1.0	100	TO-3	6-237,243
SE9301	SE9401	80	1K/-	4.0	2.0	4.0	1.0	70	TO-220	6-235,241

*TYPICAL VALUE

SELECTION GUIDE BY $I_{C(max)}$, POLARITY AND ASCENDING V_{CEO}

DEVICE POLARITY NPN	PNP	V_{CEO} Max V	h_{FE} Min/Max @	I_C A	$V_{CE(sat)}$ Max @	I_C A	f_T Min MHz	$P_{D(Max)}$ T_C = 25°C W	PACK-AGE	DATA SHEET PAGE NO
I_C = 10.0 A Max Continuous (Cont'd)										
2N6385		80	1K/20K	5.0	2.0	5.0	20	100	TO-3	6-170
SE9302	SE9402	100	1K/-	4.0	2.0	4.0	1.0	70	TO-220	6-235,241
SE9305	SE9405	100	1K/-	4.0	2.0	4.0	1.0	100	TO-3	6-237,243
2N6249		200	10/50	10	1.5	10	2.5	100	TO-3	6-158
2N6250		275	8/50	10	1.5	10	2.5	100	TO-3	6-158
FT430		300	15/45	2.5	0.9	2.5		125	TO-3	6-218
FT431		325	15/35	2.5	0.7	2.5		125	TO-3	6-218
FT359		350	250/-	3.0	2.8	7.0		125	TO-3	6-208
2N6251		350	6/50	10	1.5	10	2.5	100	TO-3	6-158
I_C = 12.0 A Max Continuous										
2N6569		40	15/200	0.2	1.5	4.0	1.5	100	TO-3	6-184
2N6057	2N6050	60	750/18K	6.0	2.0	6.0	4.0	150	TO-3	6-143,134
2N5881	2N5879	60	20/100	6.0	1.0	7.0	4.0	160	TO-3	6-123,120
2N5882	2N5880	80	20/100	6.0	1.0	7.0	4.0	160	TO-3	6-123,120
2N6058	2N6051	80	750/18K	6.0	2.0	6.0	4.0	150	TO-3	6-143,134
2N6059	2N6052	100	750/18K	6.0	2.0	6.0	4.0	150	TO-3	6-143,134
I_C = 15.0 A Max Continuous										
2N6486	2N6489	40	20/150	5.0	1.3	5.0	5.0	75	TO-220	6-180,182
2N6576		60	2K/20K	4.0	4.0	15	10	120	TO-3	6-186
2N3055SD		60	20/70	4.0	1.1	4.0	0.8	115	TO-3	6-8
FT3055	FT2955	60	20/70	4.0	1.1	4.0	2.0	70	TO-220	6-222,220
2N3055		60	20/70	4.0	1.1	4.0		117	TO-3	6-6
2N6487	2N6490	60	20/150	5.0	1.3	5.0	5.0	75	TO-220	6-180,182
2N6488	2N6491	80	20/150	5.0	1.3	5.0	5.0	75	TO-220	6-180,182
2N6577		90	2K/20K	4.0	4.0	15	10	120	TO-3	6-186
I_C = 16.0 A Max Continuous										
2N5629		100	25/100	8.0	1.0	10	0.5	200	TO-3	6-90
	2N6029	100	25/100	8.0	2.0	16	1.0	200	TO-3	6-132
2N5630		120	20/80	8.0	1.0	10	0.5	200	TO-3	6-90
	2N6030	120	20/80	8.0	2.0	16	1.0	200	TO-3	6-132
2N5631		140	15/60	8.0	1.0	10	0.5	200	TO-3	6-90
	2N6031	140	15/60	8.0	2.0	16	1.0	200	TO-3	6-132
I_C = 20.0 A Max Continuous										
2N3772		60	15/60	10	1.4	10	0.2	150	TO-3	6-22
2N5885	2N5883	60	20/100	10	1.0	15	4.0	200	TO-3	6-129,126
2N6282	2N6285	60	750/18K	10	2.0	10	4.0	160	TO-3	6-161,164
2N5039		75	20/100	10	1.0	10	60	140	TO-3	6-60
2N6283	2N6286	80	750/18K	10	2.0	10	4.0	160	TO-3	6-161,164
2N5886	2N5884	80	20/100	10	1.0	15	4.0	200	TO-3	6-129,126
2N5303		80	15/60	10	2.0	20	2.0	200	TO-3	6-69
2N5038		90	20/100	12	1.0	12	60	140	TO-3	6-60
2N6284	2N6287	100	750/18K	10	2.0	10	4.0	160	TO-3	6-161,164
I_C = 30.0A Max Continuous										
2N3771		40	15/60	15	2.0	15	0.2	150	TO-3	6-22
	2N4398	40	15/60	15	1.0	15	4.0	200	TO-3	6-37
2N5301		40	15/60	15	2.0	20	2.0	200	TO-3	6-69
	2N4399	60	15/60	15	1.0	15	4.0	200	TO-3	6-37
2N5302		60	15/60	15	2.0	20	2.0	200	TO-3	6-69
MJ802	MJ4502	90	25/100	7.5	0.8	7.5	2.0	200	TO-3	6-224,226

*TYPICAL VALUE

SELECTION GUIDE BY $I_{C(max)}$, POLARITY AND ASCENDING V_{CEO}

DEVICE POLARITY NPN	DEVICE POLARITY PNP	V_{CEO} Max V	h_{FE} Min/Max @ I_C A	$V_{CE(sat)}$ Max @ I_C V A	f_T Min MHz	$P_{D(Max)}$ T_C = 25°C W	PACK-AGE	DATA SHEET PAGE NO.
I_C = 50.0 A Max Continuous								
2N5685	2N5683	60	15/60 25	1.0 25	2.0	300	TO-3	6-101,98
2N5686	2N5684	80	15/60 25	1.0 25	2.0	300	TO-3	6-101,98

*TYPICAL VALUE

SELECTION GUIDE BY PACKAGE, ASCENDING $I_{C(max)}$ AND $V_{CEO(max)}$

DEVICE POLARITY NPN	PNP	I_C Max A	V_{CEO} Max A	h_{FE} Min/Max @ I_C A	$V_{CE(sat)}$ Max @ I_C V	A	f_T Min MHz	$P_{D(Max)}$ T_C=25°C W	DATA SHEET PAGE NO.
TO-220 Package									
TIP61	TIP62	0.5	40	40/- 0.5	0.7	0.5	3.0	15	6-261,263
TIP61A	TIP62A	0.5	60	40/- 0.5	0.7	0.5	3.0	15	6-261,263
TIP61B	TIP62B	0.5	80	40/- 0.5	0.7	0.5	3.0	15	6-261,263
TIP61C	TIP62C	0.5	100	40/- 0.5	0.7	0.5	3.0	15	6-261,263
FT47		1.0	250	30/150 0.3	1.0	1.0	10	40	6-204
FT48		1.0	300	30/150 0.3	1.0	1.0	10	40	6-204
FT49		1.0	350	30/150 0.3	1.0	1.0	10	40	6-204
FT50		1.0	400	30/150 0.3	1.0	1.0	10	40	6-204
TIP110	TIP115	2.0	60	1K/- 1.0	2.5	2.0	-	50	6-265,267
TIP111	TIP116	2.0	80	1K/- 1.0	2.5	2.0	-	50	6-265,267
TIP112	TIP117	2.0	100	1K/- 1.0	2.5	2.0	-	50	6-265,267
TIP29	TIP30	3.0	40	15/75 1.0	0.7	1.0	3.0	30	6-245,248
TIP29A	TIP30A	3.0	60	15/75 1.0	0.7	1.0	3.0	30	6-245,248
TIP29B	TIP30B	3.0	80	15/75 1.0	0.7	1.0	3.0	30	6-245,248
TIP29C	TIP30C	3.0	100	15/75 1.0	0.7	1.0	3.0	30	6-245,248
BD221	BD224	4.0	40	30/120 1.0	1.0	1.0	0.8	36	6-191,194
2N6121	2N6124	4.0	45	25/100 1.5	0.6	1.5	2.5	40	6-146,149
BD222	BD225	4.0	60	20/80 1.5	1.0	1.5	0.8	36	6-191,194
2N6122	2N6125	4.0	60	25/100 1.5	0.6	1.5	2.5	40	6-146,149
BD220	BD223	4.0	70	30/120 0.5	1.0	0.5	0.8	36	6-191,194
2N6123	2N6126	4.0	80	20/80 1.5	0.6	1.5	2.5	40	6-146,149
2N6473	2N6475	4.0	100	15/150 1.5	1.2	1.5	10	40	6-176,178
FT317	FT417	4.0	100	35/- 1.0	0.5	1.0	20	40	6-206,216
2N6474	2N6476	4.0	120	15/150 1.5	1.2	1.5	10	40	6-176,178
FT317A	FT417A	4.0	120	35/- 1.0	0.5	1.0	20	40	6-206,216
FT317B	FT417B	4.0	140	35/- 1.0	0.5	1.0	20	40	6-206,216
TIP31	TIP32	5.0	40	10/50 3.0	1.2	3.0	3.0	40	6-251,254
TIP120	TIP125	5.0	60	1K/- 0.5	2.0	3.0	-	65	6-269,271
TIP31A	TIP32A	5.0	60	10/50 3.0	1.2	3.0	3.0	40	6-251,254
TIP121	TIP126	5.0	80	1K/- 0.5	2.0	3.0	-	65	6-269,271
TIP31B	TIP32B	5.0	80	10/50 3.0	1.2	3.0	3.0	40	6-251,254
TIP122	TIP127	5.0	100	1K/- 0.5	2.0	3.0	-	65	6-269,271
TIP31C	TIP32C	5.0	100	10/50 3.0	1.2	3.0	3.0	40	6-251,254
TIP41	TIP42	6.0	40	30/- 0.3	1.5	6.0	3.0	65	6-257,259
TIP41A	TIP42A	6.0	60	30/- 0.3	1.5	6.0	3.0	65	6-257,259
TIP41B	TIP42B	6.0	80	30/- 0.3	1.5	6.0	3.0	65	6-257,259
TIP41C	TIP42C	6.0	100	30/- 0.3	1.5	6.0	3.0	65	6-257,259
2N6129	2N6132	7.0	40	20/100 2.5	1.4	7.0	2.5	50	6-152,155
2N6130	2N6133	7.0	60	20/100 2.5	1.4	7.0	2.5	50	6-152,155
2N6131	2N6134	7.0	80	20/100 2.5	2.0	7.0	2.5	50	6-152,155
2N6386		10	40	1K/20K 3.0	2.0	3.0	20	40	6-180
FT3055	FT2955	10	60	20/70 4.0	1.1	4.0	2.0	70	6-222,220
MJE3055F		10	60	20/70 4.0	1.1	4.0	2.0	70	6-228
SE9300	SE9400	10	60	1K/- 4.0	2.0	4.0	1.0	70	6-235,241
2N6387		10	60	1K/20K 3.0	2.0	3.0	20	40	6-173

SELECTION GUIDE BY PACKAGE, ASCENDING $I_{C(max)}$ AND $V_{CEO(max)}$

DEVICE POLARITY NPN	PNP	I_C Max A	V_{CEO} Max A	h_{FE} Min/Max @ I_C A		$V_{CE(sat)}$ Max @ I_C V	A	f_T Min MHz	$P_{D(Max)}$ T_C=25°C W	DATA SHEET PAGE NO.
TO-220 Package										
SE9301	SE9401	10	80	1K/-	4.0	2.0	4.0	1.0	70	6-235,241
2N6388		10	80	1K/20K	3.0	2.0	3.0	20	40	6-173
SE9302	SE9402	10	100	1K/-	4.0	2.0	4.0	1.0	70	6-235,241
2N6486	2N6489	15	40	20/150	5.0	1.3	5.0	5.0	75	6-180,182
2N6487	2N6490	15	60	20/150	5.0	1.3	5.0	5.0	75	6-180,182
2N6488	2N6491	15	80	20/150	5.0	1.3	5.0	5.0	75	6-180,182
TO-39 Package										
BF257		0.1	160	25/-	0.03	1.0	0.03	75*	1.0	6-200
BF336		0.1	180	20/-	0.03	-	-	50	1.0	6-202
BF337		0.1	200	20/-	0.03	-	-	50	1.0	6-202
BF338		0.1	225	20/-	0.03	-	-	50	1.0	6-202
BF258		0.1	250	25/-	0.03	1.0	0.03	75*	1.0	6-200
BF259		0.1	300	25/-	0.03	1.0	0.03	75*	1.0	6-200
2N5058		0.15	300	35/150	0.03	1.0	0.03	30	1.0	6-63
2N5059		0.15	250	30/150	0.03	1.0	0.03	30	1.0	6-63
SE7055		0.5	220	40/-	0.01	1.0	0.02	50	1.0	6-232
SE7056		0.5	300	40/-	0.01	1.0	0.02	50	1.0	6-232
2N5681	2N5679	1.0	100	40/150	0.25	1.0	0.5	30	10	6-94,92
2N5682	2N5680	1.0	120	40/150	0.25	1.0	0.5	30	10	6-95,92
	2N5415	1.0	200	30/150	0.05	2.5	0.05	15	10	6-87
2N3440		1.0	250	40/160	0.02	0.5	0.05	15	10	6-10
	2N5416	1.0	300	30/120	0.05	2.0	0.05	15	10	6-87
2N3439		1.0	350	40/160	0.02	0.5	0.05	15	10	6-10
2N5321	2N5323	2.0	50	40/250	0.5	0.8	0.5	50	10	6-72,75
2N5320	2N5322	2.0	75	30/130	0.5	0.5	0.5	50	10	6-72,75
2N4237	2N4234	4.0/3.0	40	30/150	0.25	0.6	1.0	1.0	6.0	6-34,31
2N5334		3.0	60	30/150	1.0	0.7	2.0	40	6.0	6-78
2N4238	2N4235	4.0/3.0	60	30/150	0.25	0.6	1.0	1.0	6.0	6-34,31
2N4239	2N4236	4.0/3.0	80	30/150	0.25	0.6	1.0	1.0	6.0	6-34,31
2N5335		3.0	80	30/150	1.0	0.7	2.0	40	6.0	6-78
BC323		5.0	60	50/250	0.5	0.15	0.5	-	7.0	6-189
BFX34		5.0	60	40/150	2.0	1.0	5.0	70	5.0	6-197
2N4895		5.0	60	40/120	2.0	1.0	5.0	50	7.0	6-40
2N4896		5.0	60	100/300	2.0	1.0	5.0	80	7.0	6-40
2N4897		5.0	80	40/120	2.0	1.0	5.0	50	7.0	6-40
2N5336		5.0	80	30/120	2.0	0.7	2.0	30	6.0	6-81
2N5337		5.0	80	60/240	2.0	0.7	2.0	30	6.0	6-81
2N5338		5.0	100	30/120	2.0	0.7	2.0	30	6.0	6-84
2N5339		5.0	100	60/240	2.0	0.7	2.0	30	6.0	6-84
TO-66 Package										
	2N4898	1.0	40	20/100	0.5	0.6	1.0	3.0	25	6-43
2N4910		1.0	40	20/100	0.5	0.6	1.0	4.0	25	6-54
	2N3740	1.0	60	30/100	0.25	0.6	1.0	4.0	25	6-16
2N4911		1.0	60	20/100	0.5	0.5	1.0	4.0	25	6-54
	2N4899	1.0	60	20/100	0.5	0.6	1.0	3.0	25	6-43

*TYPICAL VALUE

SELECTION GUIDE BY PACKAGE, ASCENDING $I_{C(max)}$ AND $V_{CEO(max)}$

DEVICE POLARITY NPN	PNP	I_C Max A	V_{CEO} Max A	h_{FE} Min/Max @ I_C A		$V_{CE(sat)}$ Max @ I_C V	A	f_T Min MHz	$P_{D(Max)}$ T_C=25°C W	DATA SHEET PAGE NO.
TO-66 Package										
	2N3741	1.0	80	30/100	0.25	0.6	1.0	4.0	25	6-16
	2N4900	1.0	80	20/100	0.5	0.6	1.0	3.0	25	6-43
2N4912		1.0	80	20/100	0.5	0.6	1.0	5.0	25	6-54
SE9331		1.0	300	30/250	0.1	2.5	0.1	10	20	6-239
2N3766		3.0	60	40/160	0.5	1.0	0.5	10	20	6-19
2N3767		3.0	80	40/160	0.5	1.0	0.5	10	20	6-19
2N4231		4.0	40	25/100	1.5	0.7	1.5	4.0	35	6-28
2N3054		4.0	55	25/150	0.5	1.0	0.5	-	25	6-3
2N4232		4.0	60	25/100	1.5	0.7	1.5	4.0	35	6-28
2N4233		4.0	80	25/100	1.5	0.7	1.5	4.0	35	6-28
TO-3 Package										
FT401		2.0	300	20/100	0.5	0.8	0.5	2.0	100	6-210
2N5838		3.0	250	8/40	3.0	1.0	3.0	5.0	100	6-105
2N5339		3.0	275	10/50	2.0	1.5	2.0	5.0	100	6-84
2N5840		3.0	350	10/50	2.0	1.5	2.0	5.0	100	6-105
FT402		3.5	325	20/100	0.5	2.0	3.0	2.0	100	6-210
	2N4901	5.0	40	20/80	1.0	1.5	5.0	4.0	87.5	6-46
2N5067		5.0	40	20/80	1.0	0.4	1.0	4.0	87.5	6-66
2N4913	2N4904	5.0	40	25/100	2.5	1.5	5.0	4.0	87.5	6-57,49
2N5068		5.0	60	20/80	1.0	0.4	1.0	4.0	87.5	6-66
	2N4902	5.0	60	20/80	1.0	1.5	5.0	4.0	87.5	6-46
2N4914	2N4905	5.0	60	25/100	2.5	1.5	5.0	4.0	87.5	6-57,49
	2N4903	5.0	80	20/80	1.0	1.5	5.0	4.0	87.5	6-46
2N5069		5.0	80	20/80	1.0	0.4	1.0	4.0	87.5	6-66
2N4915	2N4906	5.0	80	25/100	2.5	1.5	5.0	4.0	87.5	6-57,49
2N5873	2N5871	7.0	60	20/100	2.5	1.0	4.0	4.0	115	6-111,108
2N5874	2N5872	7.0	80	20/100	2.5	1.0	4.0	4.0	115	6-111,108
FT410		7.5	200	30/90	1.0	0.8	1.0	-	100	6-210
FT411		7.5	300	30/90	1.0	0.8	1.0	-	100	6-212
FT413		7.5	325	20/80	0.5	0.8	0.5	-	100	6-214
FT423		7.5	325	30/90	1.0	0.8	1.0	-	100	6-214
2N5877	2N5875	8.0	60	20/100	4.0	1.0	5.0	4.0	150	6-117,114
2N6055	2N6053	8.0	60	750/18K	4.0	2.0	4.0	4.0	100	6-140,137
2N5878	2N5876	8.0	80	20/100	4.0	1.0	5.0	4.0	150	6-117,114
2N6056	2N6054	8.0	80	750/18K	4.0	2.0	4.0	4.0	100	6-140,137
2N6306		8.0	250	15/75	3.0	0.8	3.0	5.0	125	6-137
2N6307M		8.0	300	15/75	3.0	1.0	3.0	5.0	125	6-167
2N6308M		8.0	350	12/60	3.0	1.5	3.0	5.0	125	6-167
	2N4907	10	40	20/80	4.0	0.75	4.0	4.0	150	6-52
2N6383		10	40	1K/20K	5.0	2.0	5.0	20	100	6-170
	2N3789	10	60	25/90	1.0	1.0	5.0	4.0	150	6-25
2N3713		10	60	25/75	1.0	1.0	5.0	4.0	150	6-13
	2N4908	10	60	20/80	4.0	0.75	4.0	4.0	150	6-52
2N3715		10	60	50/150	1.0	0.8	5.0	2.5	150	6-13
	2N3791	10	60	50/180	1.0	1.0	5.0	4.0	150	6-25
2N6384		10	60	1K/20K	5.0	2.0	5.0	20	100	6-170

SELECTION GUIDE BY PACKAGE, ASCENDING $I_{C(max)}$ AND $V_{CEO(max)}$

DEVICE POLARITY NPN	PNP	I_C Max A	V_{CEO} Max A	h_{FE} Min/Max @ I_C A		$V_{CE(sat)}$ Max @ I_C V	A	f_T Min MHz	$P_{D(Max)}$ T_C=25°C W	DATA SHEET PAGE NO.
TO-3 Package										
	2N3792	10	80	50/180	1.0	1.0	5.0	4.0	150	6-25
SE9304	SE9404	10	80	1K/-	4.0	2.0	4.0	1.0	100	6-237,243
2N6385		10	80	1K/20K	5.0	2.0	5.0	20	100	6-170
SE9305	SE9405	10	100	1K/-	4.0	2.0	4.0	1.0	100	6-237,243
2N6249		10	200	10/50	10	1.5	10	2.5	100	6-158
2N6250		10	275	8/50	10	1.5	10	2.5	100	6-158
FT431		10	325	15/35	2.5	0.7	2.5	-	125	6-218
2N6251		10	350	6/50	10	1.5	10	2.5	100	6-158
FT359		10	350	250/-	3.0	2.8	7.0	-	125	6-208
FT430		10	300	15/45	2.5	0.9	2.5	-	125	6-218
2N6569		12	40	15/200	4.0	1.5	4.0	1.5	100	6-184
2N5881	2N5879	12	60	20/100	6.0	1.0	7.0	4.0	160	6-123,120
2N6057	2N6050	12	60	750/18K	6.0	2.0	6.0	4.0	150	6-134,143
2N5882	2N5880	12	80	20/100	6.0	1.0	7.0	4.0	160	6-123,120
2N6058	2N6051	12	80	750/18K	6.0	2.0	6.0	4.0	150	6-143,134
2N6059	2N6052	12	100	750/18K	6.0	2.0	6.0	4.0	150	6-143,134
2N3055		15	60	20/70	4.0	1.1	4.0	-	117	6-6
2N3055SD		15	60	20/70	4.0	1.1	4.0	0.8	115	6-8
2N6576		15	60	2K/20K	4.0	4.0	15	10	120	6-186
2N6577		15	90	2K/20K	4.0	4.0	15	10	120	6-186
	2N6029	16	100	25/100	8.0	2.0	16	1.0	200	6-132
2N5629		16	100	25/100	8.0	1.0	10	0.5	200	6-90
	2N6030	16	120	20/80	8.0	2.0	16	1.0	200	6-132
2N5630		16	120	20/80	8.0	1.0	10	0.5	200	6-90
	2N6031	16	140	15/60	8.0	2.0	16	1.0	200	6-132
2N5631		16	140	15/60	8.0	1.0	10	0.5	200	6-90
2N3772		20	60	15/60	10	1.4	10	0.2	150	6-22
2N5885	2N5883	20	60	20/100	10	1.0	15	4.0	200	6-129,126
2N6282	2N6285	20	60	750/18K	10	2.0	10	4.0	160	6-161,164
2N5039		20	75	20/100	10	1.0	10	60	140	6-60
2N5886	2N5884	20	80	20/100	10	1.0	15	4.0	200	6-129,126
2N6283	2N6286	20	80	750/18K	10	2.0	10	4.0	160	6-161,164
2N5303		20	80	15/60	10	2.0	20	2.0	200	6-69
2N5038		20	90	20/100	12	1.0	12	60	140	6-60
2N6284	2N6287	20	100	750/18K	10	2.0	10	4.0	160	6-161,164
	2N4398	30	40	15/60	15	1.0	15	4.0	200	6-37
	2N4399	30	60	15/60	15	1.0	15	4.0	200	6-37
2N3771		30	40	15/60	15	2.0	15	0.2	150	6-22
2N5301		30	40	15/60	15	2.0	20	2.0	200	6-69
2N5302		30	60	15/60	15	2.0	20	2.0	200	6-69
MJ802	MJ4502	30	90	25/100	7.5	0.8	7.5	2.0	200	6-224,226
2N5685	2N5683	50	60	15/60	25	1.0	25	2.0	300	6-98,101
2N5686	2N5684	50	80	15/60	25	1.0	25	2.0	300	6-98,101

DARLINGTON SELECTION GUIDE BY $I_{C(max)}$ AND $V_{CEO(max)}$

DEVICE POLARITY NPN	PNP	V_{CEO} Max V	h_{FE} Min/Max at I_C	A	$V_{CE(sat)}$ Max at I_C V	A	f_T Min MHz	$P_{D(Max)}$ T_C=25°C W	PACK-AGE	DATA SHEET PAGE NO
I_C = 2.0 A Max Continuous										
TIP110	TIP115	60	1K/-	1.0	2.5	2.0	-	50	TO-220	6-265
TIP111	TIP116	80	1K/-	1.0	2.5	2.0	-	50	TO-220	6-265
TIP112	TIP117	100	1K/-	1.0	2.5	2.0	-	50	TO-220	6-265
I_C = 5.0 A Max Continuous										
TIP120	TIP125	60	1K/-	0.5	2.0	3.0	-	65	TO-220	6-267,271
TIP121	TIP126	80	1K/-	0.5	2.0	3.0	-	65	TO-220	6-269,271
TIP122	TIP127	100	1K/-	0.5	2.0	3.0	-	65	TO-220	6-269,271
I_C = 8.0 A Max Continuous										
2N6055	2N6053	60	750/18K	4.0	2.0	4.0	4.0	100	TO-3	6-140,137
2N6056	2N6054	80	750/18K	4.0	2.0	4.0	4.0	100	TO-3	6-140,137
I_C = 10.0 A Max Continuous										
2N6386		40	1K/20K	3.0	2.0	3.0	20	40	TO-220	6-173
2N6383		40	1K/20K	5.0	2.0	5.0	20	100	TO-3	6-170
2N6387		60	1K/20K	3.0	2.0	3.0	20	40	TO-220	6-173
SE9300	SE9400	60	1K/-	4.0	2.0	4.0	1.0	70	TO220	6-235,241
SE9303	SE9403	60	1K/-	4.0	2.0	4.0	1.0	100	TO-3	6-237,243
2N6384		60	1K/20K	5.0	2.0	5.0	20	100	TO-3	6-170
2N6388		80	1K/20K	3.0	2.0	3.0	20	40	TO-220	6-173
SE9304	SE9404	80	1K/-	4.0	2.0	4.0	1.0	100	TO-3	6-237,243
SE9301	SE9401	80	1K/-	4.0	2.0	4.0	1.0	70	TO-220	6-235,241
2N6385		80	1K/20K	5.0	2.0	5.0	20	100	TO-3	6-170
SE9302	SE9402	100	1K/-	4.0	2.0	4.0	1.0	70	TO-220	6-235,241
SE9305	SE9405	100	1K/-	4.0	2.0	4.0	1.0	100	TO-3	6-237,243
FT359		350	250/-	3.0	2.5	7.0	-	125	TO-3	6-208
I_C = 12 A Max Continuous										
2N6057	2N6050	60	750/18K	6.0	2.0	6.0	4.0	150	TO-3	6-143,134
2N6058	2N6051	80	750/18K	6.0	2.0	6.0	4.0	150	TO-3	6-143,134
2N6059	2N6052	100	750/18K	6.0	2.0	6.0	4.0	150	TO-3	6-143,134
I_C = 15 A Max Continuous										
2N6576		60	2K/20K	4.0	4.0	15	10	120	TO-3	6-186
2N6577		90	2K/20K	4.0	4.0	15	10	120	TO-3	6-186
I_C = 20 A Max Continuous										
2N6282	2N6285	60	750/18K	10	2.0	10	4.0	160	TO-3	6-161,164
2N6283	2N6286	80	750/18K	10	2.0	10	4.0	160	TO-3	6-161,164
2N6284	2N6287	100	750/18K	10	2.0	10	4.0	160	TO-3	6-161,164

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2N2987	2N5335
2N2988	2N5681
2N2989	2N5681
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2N3173	2N3790
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2N3421	2N5336
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2N3448	2N5878
2N3469	2N5337
2N3506	2N5337
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2N3589	SE9331
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2N3636	FT5416
2N3660	2N4234
2N3661	2N4235
2N3675	2N4238
2N3676	2N4239
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2N3714	2N3714
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2N3716	2N3716
2N3719	2N4234
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2N4113	2N5877/ 2N3716
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2N5195	2N6126
2N5202	2N5874
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2N5237	2N5237
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2N5987	FT2955
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2N6246	2N5879
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2N6258	2N5886
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2N6261	2N3767/ 2N4233
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2N6301	SE9304
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2N6330	2N3792
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2N6411	BD224
2N6412	BD221
2N6413	BD222
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2N6415	BD225
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40251	2N6569

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40309	2N5321
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40311	2N5321
40312	2N3054
40313	SE9331
40314	2N5321
40315	2N5321
40316	2N3054
40317	2N5321
40318	SE9331
40319	2N5323
40320	2N5321
40321	2N3440
40322	SE9331
40323	2N5321
40324	2N3054
40325	2N6569
40326	2N5321
40327	2N3440
40328	SE9331
40346	2N3440
40347	2N5321
40348	2N4238
40360	2N5320
40361	2N5320
40362	2N5322
40363	2N3055
40366	2N5320
40367	2N4238
40369	2N5873
40372	2N3054
40375	2N5873
40385	2N3439
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40391	2N5323
40394	2N5323
40411	MJ802
40412	2N3440
40594	2N5338
40613	TIP29
40618	BD221
40621	BD221
40622	BD221
40624	2N6129
40626	2N5629
40627	2N6130
40629	2N6122
40630	2N6122
40631	2N6122
40632	2N6131
40636	2N5630
40850	FT401
40851	2N6251
40852	2N6251
40853	FT430

Industry Type Number	Fairchild Nearest Standard
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40886	FT48
40887	FT49
40910	2N4231
40911	2N5233
41500	TIP31
41501	TIP32
41502	2N4237
41503	2N4234
41504	BD224
41505	FT47
41506	2N5838
43104	2N5631
BD111A	2N3715
BD117	2N3713
BD124	2N3054
BD127	FT48
BD128	FT49
BD129	FT50
BD135	TIP29
BD136	TIP30
BD137	TIP29A
BD138	TIP30A
BD139	TIP29B
BD140	TIP30B
BD141	2N5631
BD142	2N6569
BD157	FT47
BD158	FT48
BD159	FT49
BD163	2N5054
BD165	TIP29
BD166	TIP30
BD167	TIP29A
BD168	TIP30A
BD169	TIP29B
BD170	TIP30B
BD175	2N6121
BD176	2N6124
BD177	TIP29A
BD178	TIP30A
BD179	TIP29B
BD180	TIP30B
BD185	BD221
BD186	BD224
BD187	2N6121
BD188	2N6124
BD189	BD222
BD190	BD225
BD195	2N6129
BD196	2N6132
BD197	2N6129
BD198	2N6132
BD199	2N6130
BD200	2N6133

Industry Type Number	Fairchild Nearest Standard
BD205	2N6569
BD207	FT3055
BD208	FT2955
BD213/60	FT3055
BD214/60	FT2955
BD233	TIP29
BD234	TIP30
BD235	TIP29A
BD236	TIP30A
BD237	TIP29B
BD238	TIP30B
BD260	FT401
BD261	FT411
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BD318	2N6020
BD361	TIP29
BD361A	TIP29
BD362	TIP30
BD362A	TIP30
BD561	2N2161
BD562	2N2164
BD575	TIP29
BD576	TIP30
BD577	TIP29A
BD578	TIP30A
BD579	TIP29B
BD580	TIP30B
BD585	2N6121
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BD599	2N6131
BD600	2N6134
BD607	FT3055
BD608	FT2955
BD697	SE9300
BD697A	SE9300
BD699	SE9301
BD699A	SE9301

Industry Type Number	Fairchild Nearest Standard
BD700	SE9401
BD700A	SE9401
BDX10	2N3055
BDX11	2N5631
BDX13	2N6569
BDX23	2N5629
BDX24	2N4913
BDX40	2N3772
BDX50	2N5631
BDX51	2N5630
BDX60	2N5629
BDX61	2N5886
BDX70	FT3055
BDX71	FT3055
BU100A	2N5629
BU102	2N5631
BU120	2N6249
BU125	2N4895
BU127	2N5630
BU128	2N6249
BUY24	2N5068
BUY38	2N3054
BUY46	2N3054
BUY68	2N4895/96
B133000	BD221
B133001	BD221
B133002	BD221
B133003	2N6122
B133004	2N6122
B133005	2N6122
B133006	2N6123
B133007	2N6123
B133008	2N6123
B170000	2N6569
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B170016	2N5629
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B170018	2N6569
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B170020	2N6569
B170021	2N5882

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Industry Type Number	Fairchild Nearest Standard
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B170024	2N5629
B170025	2N5629
B170026	2N5629
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B176006	FT423
B176007	FT423
B176024	FT423
B176025	FT423
DTS401	FT401
DTS402	FT402
DTS403	FT402
DTS409	FT402
DTS410	FT410
DTS411	FT411
DTS413	FT413
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INDUSTRY CROSS REFERENCE

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INDUSTRY CROSS REFERENCE

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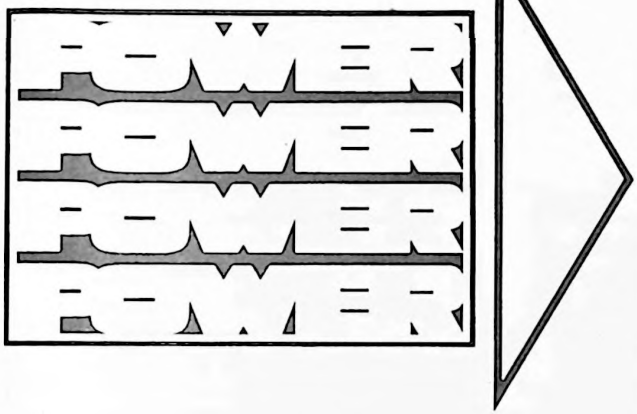

DEVICE SELECTION GUIDES AND CROSS REFERENCE

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POWER TRANSISTOR MANUFACTURING 3

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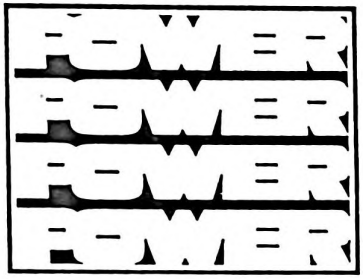


CHAPTER 1

- Structures
- Geometries
- Design Consideration
- Conclusion

Chapter 1
POWER TRANSISTOR TECHNOLOGY

Advances in power transistor design are continuously providing higher power output, improved efficiency and better frequency response. Power transistors can handle currents in excess of 100 A, voltages up to 3000 V, large power dissipation, and drastic current and voltage surges. In addition, they exhibit several phenomena which are of little importance in small signal transistors—conductivity modulation, base widening, emitter current crowding, second breakdown, high voltage surface effects and thermal fatigue.

Power transistor fabrication methods vary. Small-signal transistors and integrated circuits are generally constructed using many steps of rather shallow diffusions into an epitaxial layer supported by a low resistivity substrate. Power transistors are manufactured using at least six basically different technologies—double-diffused epitaxial Planar*, triple-diffused Planar, single epitaxial-base mesa, multiple epitaxial-base mesa, multiple-epitaxial double-diffused mesa and single diffused (hometaxial). Each structure eliminates one or more of the phenomena mentioned above and differs significantly from the others in characteristics and performance. The structure and geometry of each technique have an important impact on deciding which power transistor will give the optimum performance in a particular application. Fairchild uses four of these processing technologies—double-diffused epitaxial Planar, single epitaxial-base mesa, multiple epitaxial-base mesa and multiple-epitaxial double-diffused mesa—to provide highly reliable low-cost power transistors with maximum performance capabilities.

STRUCTURES *(Figure 1-1)*

Double-Diffused Epitaxial Planar

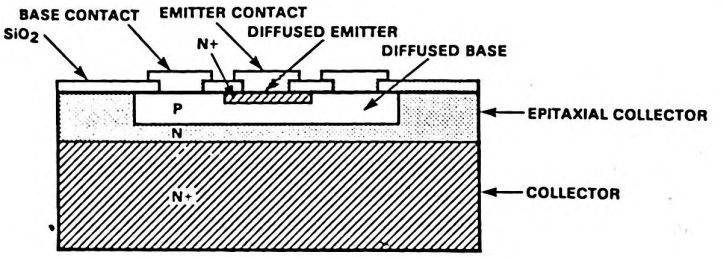
These power transistors, made by the same process used for small-signal transistors, are characterized by shallow diffusions into an epitaxial layer. The junctions are normally passivated with silicon dioxide to ensure low leakage currents and optimum stability. This is the most common form of Planar power transistor and both npn and pnp types can easily be made. The devices typically have very low leakage, high gain, low saturation voltage and high gain-bandwidth product. Typical values for the latter range from 20 to 200 MHz. Double-diffused epitaxial Planar transistors are primarily used in high frequency, high reliability switching and amplifying applications with f_T ratings greater than 30 MHz and maximum collector current ratings up to 10 A.

These transistors have a relatively poor safe operating area because of the narrow base region and the depletion of the entire voltage into the collector region. Maximum die yield depends on expert photoresist techniques for diffusing impurities through an opening etched in the surface oxide. The oxide-masked and phosphorous-passivated Planar structures allow lower leakage than mesa junction devices. The structure is limited to approximately 400 V breakdown voltage. This is a result of uncontrolled surface charge introduced into the high field region associated with the finite radius of curvature of the impurity diffusion front. This results in premature breakdown. The use of metallic overlay (junction field plate) and resistive films is employed to combat these effects.

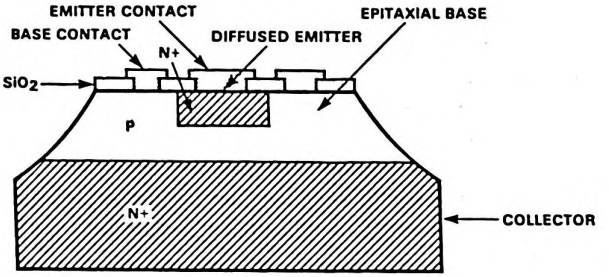
Single Epitaxial-Base Mesa

These transistors are manufactured by diffusing an emitter into an epitaxial base region deposited on the collector substrate. The collector voltage depletes into the base region. The device is fairly rugged with reasonable gain and medium f_T. The safe operating area capability is between Planar triple diffused and single diffused mesa. Epitaxial base devices gain ruggedness as a result of the wide and homogeneous base region. Both npn and pnp-type transistors can be made by this process. Performance is somewhat limited by low voltage ratings imposed by the abrupt base-collector junction formed between the heavily doped collector substrate and the epitaxially deposited base layer, and by the thickness of this layer.

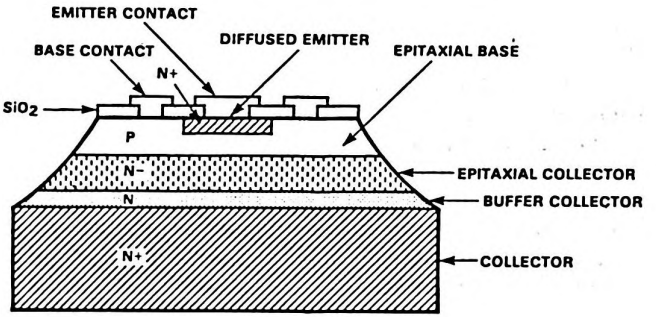
*Planar is a patented Fairchild process.



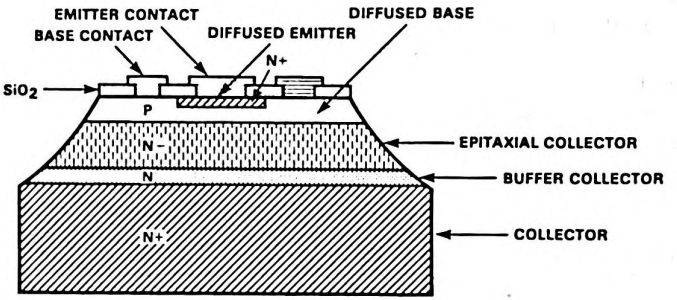
Double-Diffused Epitaxial Planar



Single Epitaxial-Base Mesa



Multiple Epitaxial-Base Mesa



Multiple-Epitaxial Double-Diffused Base Mesa

Fig. 1-1 Basic Power Transistor Structures

Multiple Epitaxial-Base Mesa

This process uses two epitaxial layers to form the collector and base regions, a mesa etch to define the collector-base junction, and Planar processing to form the emitter-base junction. This produces low-cost, high-current devices with excellent safe-area capabilities. Epitaxial-base transistors gain ruggedness as the result of the wide homogeneous base region. When compared to conventional single-diffused devices, epitaxial-base mesa transistors exhibit higher working voltage capabilities, lower saturation voltages, and lower leakage currents. Beta linearity is also improved and npn and pnp complementary devices are readily produced. Maximum current ratings extend to 50 A and f_T ratings to 15 MHz.

Multiple-Epitaxial Double-Diffused Base Mesa

This structure is identical to the double-diffused epitaxial except that multiple-epitaxial layers are used in the collector region and the collector-base junction is formed by a mesa etch. A low resistivity thin layer is epitaxially grown between the highly doped substrate and the low-epitaxial collector region. The advantages of the multiple-epitaxial double-diffused structure are high speed (f_T = 50 MHz), low saturation voltage and increased E_{SB} capability due to the epitaxial intermediate collector.

GEOMETRIES

The transistor geometry, in conjunction with its structure, establishes most of the fundamental electrical, thermal, and economic properties. Proper geometric design of a transistor provides for many compromises that can result in a variety of advantages and disadvantages from different structures.

The basic objective for most power-transistor geometry designs is to obtain the highest current handling per unit area of die. This results in lower cost designs or, as in high-frequency transistors, higher speed as a result of the smaller device areas.

Power-transistor geometries have evolved from the very early inefficient line-geometry configurations to the present-day sophisticated discrete-emitter concepts (*Figure 1-2*). Current crowding, which causes high current density, is the greatest contributor to reductions in current gain. Emitter periphery is the crucial design factor in minimizing this problem, therefore, emitter geometry is designed for high periphery-to-area ratio. The device structure dictates, to some extent, how much periphery can be made.

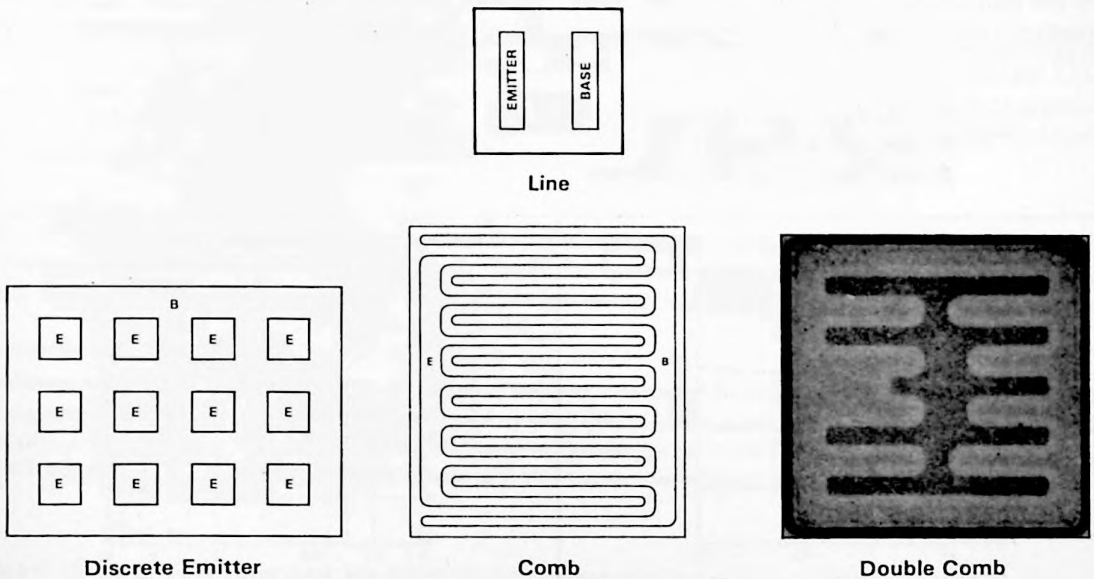


Fig. 1-2. Emitter Geometries

DESIGN CONSIDERATIONS

Power transistors, manufactured by the methods outlined above, differ in gain characteristic, frequency response, power capability and cost. Therefore, the selection of the best power transistor for any particular application amounts to a trade off among many crucial design parameters. Design considerations for power transistors are generally more complex than for small signal devices. Some generally accepted simplifications in the transistor theory are no longer valid under conditions of high voltage or high current. However, the knowledgeable device engineer can optimize the performance of a power transistor for its intended application. The design parameters may be divided into four classes—electrical, thermal, mechanical and cost.

Electrical

The electrical parameters of a power transistor are not only of importance for device performance as a switch or amplifier, but they also determine the reliability and durability of the device under various operating conditions.

Saturation

Saturation, mainly caused by collector-layer resistance, is present in all transistors but is more pronounced for high-voltage devices due to inherently higher collector resistivity (*Figure 1-3*). Low saturation voltage means low power loss for a given collector current ($P = V_{CE(sat)} \times I_C$). Low saturation voltage can be achieved by

- an epitaxial collector,
- decreased collector thickness,
- decreased collector resistivity,
- interdigitated design,
- large chip size.

Quasi Saturation

Quasi saturation, only apparent in high-voltage transistors, is evidenced by the slope of the collector current vs collector voltage (*Figure 1-3*). This effect is caused by a distortion of the collector-base density, where the density of the minority carriers approaches that of the fixed charges in the semiconductor. This leads to reduced gain due to base widening (*Figure 1-4*). The effects of quasi saturation can be minimized by

- measuring gain at higher voltages,
- decreasing collector resistivity,
- decreasing collector thickness.

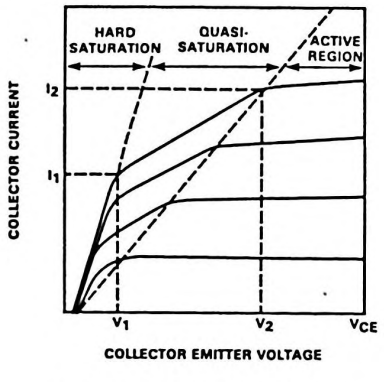


Fig. 1-3. Quasi-Saturation Region

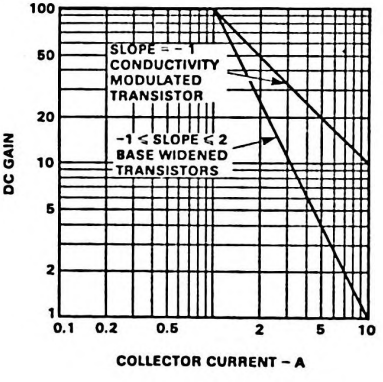


Fig. 1-4. Gain Fall

High Current Gain

High current gain is reduced by conductivity modulation and current crowding. Conductivity modulation occurs mainly in wide, high-resistivity-base transistors. It is caused by high level injection of mobile carriers in the base, thus temporarily decreasing the effective resistivity of the base and, therefore, the emitter efficiency, giving lower current gain at higher current. The negative effect of conductivity modulation on high current gain can be reduced by

- decreasing base resistivity,
- decreasing base width.

Current crowding is caused by two types of resistive debiasing. One is due to the lateral voltage drop in the base region beneath the emitter. This causes a higher base potential along the edge of the emitter and, consequently, a higher emitter current density along the emitter periphery. Since most transistors have relatively thin base structures of high resistivity, the current concentration continues through the collector-base junction and through most of the collector. Thus the effective area of the transistor is reduced and the high current gain drops off. The lateral debiasing effect can be minimized by

- reducing base resistivity beneath the emitter,
- increasing base width,
- interdigitated emitter with low width/length ratio.

Resistive debiasing along the metalization over the emitter fingers is another limiting factor on high current gain. The emitter current causes a longitudinal voltage drop in the metalization, which decreases the emitter-base voltage as the distance from the emitter bond increases. The resulting longitudinal current crowding in the vicinity of the emitter bond also reduces the effective area of the transistor. The voltage drop in the metalization can be reduced by

- lower resistivity metalization (aluminum),
- thicker metalization,
- emitter fingers with high width/length ratio.

It is evident from this discussion that the required width/length ratio of the emitter fingers to minimize both sources of current crowding are in conflict. Aside from its ill effect on current gain, current crowding is also one major cause for overheating and possible destruction. To achieve high current capability, the emitter must have a large area, be highly efficient, and inject uniformly. The interdigitated structure with many long thin fingers and aluminum metalization meets these requirements.

Non-Linear Gain

Non-linear gain in the active region is caused by the Early effects (*Figure 1-3*), *i.e.*, the gain increases with higher collector voltages. The cause of this phenomenon is the expansion of the depletion region into the base and, consequently, the narrowing of the neutral base width.

High-Voltage Surface Effects

Mesa power transistors can be made with high breakdown voltages because collector-base junctions are not seriously affected by radius effects and field-induced distortions. Leakage is highly dependent on the proper preparation of the exposed junction in the mesa groove prior to varnish passivation in the package. Any surface contamination in the mesa obviously increases the leakage current of the device.

In Planar* devices, both junctions are covered with silicon dioxide to eliminate the problems of outside contamination. Therefore, they have very low leakage currents. The breakdown voltage, however, can be limited by distortions of the depletion region from radius effects and fields induced by static charges in the oxide. Since the diffusion of the impurities in the silicon occurs laterally as well as vertically, the ra-

*Planar is a patented Fairchild process.

dius of the junction edge is equal to the depth of the diffusion. This dimension is in the order of microns, thus the electric-field strength at the curved edge of the junction is considerably increased for any given voltage. This leads to premature breakdown for curved junctions compared to plane junctions.

The presence of fixed and mobile charges in the oxide, or at the silicon-oxide interface, can induce considerable changes in the density of mobile carriers in the silicon close to the surface. Since positive charges usually dominate in the oxide, the charges tend to enhance the electron concentration in n-type silicon and to reduce the hole concentration in p-type silicon. As a consequence, the depletion region close to the surface is reduced in width on the n-side of a junction (lower breakdown voltage). Conversely, the depletion region close to the surface may be increased in width through a field-induced channel on the p-side of a junction (higher leakage through channel). In most cases these effects are only of importance for the collector-base junction, which requires higher breakdown voltage. The collector-base breakdown voltage can be increased by

- using a field plate, or
- using a voltage ring.

Thermal

Thermal design must combat thermal instability and second breakdown. Thermal instability is caused by unintentional temperature difference between various emitter locations. Current density is strongly dependent upon the temperature of the emitter-base junction. If current density is higher in some particular part of the structure, due to a defect of some sort such as a hot spot in the base layer, local temperature rise then occurs. At constant forward bias across the emitter junction, an approximately 10% increase in current occurs for every 1°C increase in temperature. Thus, the local temperature rise further increases the local current and a positive feedback situation occurs. If the gain around this feedback loop is greater than one, *i.e.*, if temperature rise produces a larger increase in current than that which originally caused the temperature rise, an unstable situation exists. Current and temperature build up locally and destroy the device. Thermal instability can be minimized by

- thinner transistor chips to allow heat in the device to be more efficiently dissipated by a heat sink,
- increased base width and decreased emitter-finger width to provide more uniform current distribution,
- increased base doping which also improves current distribution,
- a number of separate discrete emitters each with a ballasting resistor placed in series. These resistors insert a voltage drop in each emitter proportional to the current passing through the emitter, inserting current feed-back and equalizing current among the emitters.

Thermal instability can cause a serious reliability problem in power transistors, namely second breakdown. Second breakdown occurs when a bipolar transistor is operated at high power density and the emitter-collector voltage suddenly drops to a low value. Unless power is removed, overheating either destroys or materially degrades the transistor. Second breakdown (SB) is a thermal hot-spot phenomenon within the transistor die with two stages of development. The first is constriction where, because of thermal regeneration, current tends to concentrate in a small area. The second stage, destruction, occurs when local temperatures and temperature gradients increase until they cause permanent device damage.

The constriction can start any number of ways. One section of the emitter-base junction need only have a higher temperature than another. Such a hot spot might be caused by resistive debiasing, divergent heat flow to the device heat sink, an inhomogeneity in the thermal part, or other irregularities or imperfections within the device. Once a slightly hotter emitter-base region is present, positive thermal feed-

back begins; the hot region injects more and therefore gets hotter and the device goes into second breakdown. Forward biased second-breakdown current I_{SB} can be controlled by either emitter or base ballasting, which effectively equalizes drive conditions within the device and maintains uniformity. Ballasting against reverse-biased second breakdown E_{SB} can be achieved by the addition of a resistive layer in the collector which decreases the collector-emitter voltage in the affected region.

Mechanical

Power transistors are subjected to a large number of temperature changes during fabrication, screening and storage. Also, they are often used in applications where cycling the power causes repeated temperature cycling. Because transistors are constructed of materials that have different thermal coefficients of expansion, stress can be induced in the chip. Stress is a function of the difference between coefficients of expansion, the change in temperature, the respective moduli of elasticity, and the thickness. Power transistors, therefore, are made with materials having close thermal coefficients of expansion to minimize stress. Power transistors, however, require that the heat generated during operation be conducted away from the die. Material used for this heat conduction generally has a much higher coefficient of expansion than semiconductor material, especially silicon. Several techniques are used to minimize thermal fatigue. One method is to mount the chip on a metal such as molybdenum, which has a thermal coefficient of expansion similar to silicon, and braze it on a metal such as copper with very high thermal conductivity. The rate of degradation of the metallurgical bond under stress is also proportional to the average and peak temperature excursions of the bond. The most economical way to obtain reliability in a power transistor, therefore, is to reduce the temperature by careful consideration of heat flow during equipment design.

Cost Reduction

The cost of silicon power transistors is often a factor in the manufacturing method chosen. For large area devices (200 x 200 mil), cost is principally in the dice. Package cost, assembling and testing are secondary, therefore, cost reduction must be made in the wafer fabrication area. Early silicon wafers were small, only one inch in diameter, thus costs were high since each wafer undergoes the same number of processing steps regardless of size. It was obvious that increased wafer diameter would reduce cost, yields being equal. Now, most manufacturers have converted to 2-1/2- or 3-inch wafers to reduce processing cost per die. As an example, only 16 dice (200 x 200 mil) can be obtained from a 1-inch wafer while 145 dice can be obtained from a 3-inch wafer. The die cost is not reduced by this order of magnitude, however, since the raw-wafer cost is somewhat higher.

Lower die cost is often a reason for choosing a mesa approach if reliability is not the prime objective. The wafer fabrication process is shorter and the number of electrically good dice per wafer generally higher when using mesa technoloty instead of Planar. The Planar process can suffer from low yields as a result of pin holes in the passivating oxide, oxide islands left in the base cut, and accumulation of impurities along the oxide edges.

For military applications that require large transistors and high reliability, the cost of packaging, testing and processing far exceeds the cost of the dice. Even in a TO-5 package, the die cost often becomes an insignificant factor of the total transistor cost. Using a die size smaller than 80 x 80 mil and large wafers, it matters little which approach, mesa or Planar, is used as far as die cost is concerned.

CONCLUSION

The transistor designer is faced with the problem of trying to optimize transistor parameters to attain performance as close to the ideal as possible; unfortunately, this is not easy. Since each specific parameter is related to the properties and geometry of the actual transistor structure, it is not possible to optimize without getting into conflicting requirements. This is best illustrated in *Table 1-1* and *1-2* which show the behavior of the basic electrical parameters when the transistor properties are changed. Furthermore, although the design theory may show that it is conceivable to obtain a near-ideal junction transistor, it may not be practical to fabricate such a device within the limitations of the transistor state-of-the-art.

Several basic processes exist today for making junction transistors, each yielding different impurity structures. For each type, however, certain electrical parameters must be sacrificed for the sake of others. Therefore, for some circuit applications, one process type may be more suitable than another.

Physical Parameter		Electrical Parameter								
		f_T	t_d, t_r t_f, t_s	$V_{CEO(sus)}$	$V_{CE(sat)}$	V_{BE}	h_{FE} (peak)	$I_{C(max)}$	I_{SB}	E_{SB}
Base width	↑	↓	↑	↑	↑	↑	↓	↓	↑	↑
Base resistivity	↑	–	↑	–	↓	↑	↑	↓	↓	↓
Collector width	↑	↓	↑	↑	↑	↑	–	↓	–	↑
Collector resistivity	↑	↓	↑	↑	↑	↑	–	↓	↓	↓
Emitter width (finger)	↑	↓	↑	–	–	↑	–	↓	↓	↓
Emitter ballast	↑	↑	↓	–	↑	↑	–	↑	↑	–
Collector ballast	↑	↓	↑	–	↑	–	–	↓	–	↑

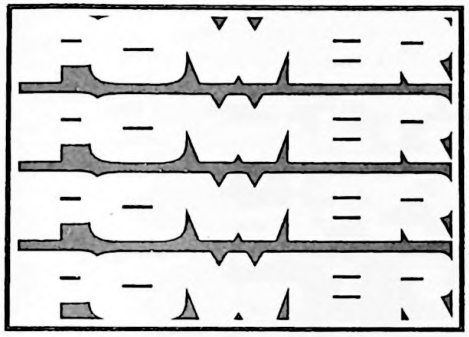
Table 1-1. Interrelation Among Physical and Electrical Parameters

Physical Parameter		Electrical Parameter					
		f_T	t_d, t_r t_f, t_s	$V_{CE(sat)}$	h_{FE} (Peak)	$I_{C(max)}$	Cost
I_{SB}	↑	↓	↑	↑	↓	↑	↑
E_{SB}	↑	↓	↑	↑	↓	↓	↑
$V_{CEO(sus)}$	↑	↓	↑	↑	–	↓	↑

Table 1-2. Interrelation Among Electrical Parameters

Symbols for Tables 1 and 2

f_T—current gain bandwidth
t_d—delay time
t_r—rise time
t_f—fall time
t_s—storage time
I_{SB}—forward second breakdown current
h_{FE}—dc current gain
$V_{CEO(sus)}$—collector to emitter voltage, base open
$V_{CE(sat)}$—collector to emitter saturation voltage
I_C—collector current (current handling)
E_{SB}—reverse second breakdown energy
↑ Increase
↓ Decrease



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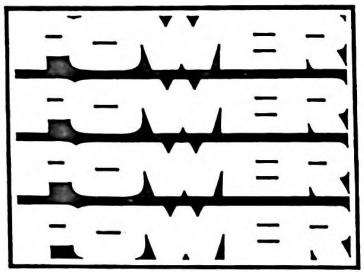


CHAPTER 2

- DC Forward-Biased Safe Operating Area
- Pulsed SOA
- Testing of Forward Biased SOA
- Reverse-Biased Safe Operating Area

Chapter 2
SAFE OPERATING AREA

A number of factors such as second breakdown, dissipation capability, current and voltage ratings, and ambient temperature critically affect the performance of power transistors in circuit applications. These factors define the safe operating areas (SOA) for the forward-biased and reverse-biased modes, within which each device can be safely operated without failure or degradation. Most manufacturers publish SOA curves to provide the circuit designer with an easy method for specifying power transistors.

DC FORWARD-BIASED SAFE OPERATING AREA

A transistor working in the active region is subjected to voltage and current at the same time and dissipates power. Figure 2-1 shows a typical safe operating area (SOA) for the active region. This is called forward-biased SOA since the base of the transistor is positive with respect to the emitter. Collector current I_C is shown as a function of collector-to-emitter voltage V_{CE}. Each curve is labeled with the duration of the on pulse – from the worst-case dc condition to a minimum duration of 5 μs – at T_C = 25°C and a 1% duty cycle. The four factors limiting the dc forward-biased SOA of a particular power transistor are the collector current (1), thermal limitations (2), second breakdown (3), and open base breakdown voltage, $V_{CEO(sus)}$ (4).

IC - Limit (1 on the SOA curve in Figure 2-1)
The I_C is limited by the current handling capability of the bonding wires. For current pulses, the limit is higher than for dc since the thermal capacitance of the wire prevents instantaneous heating.

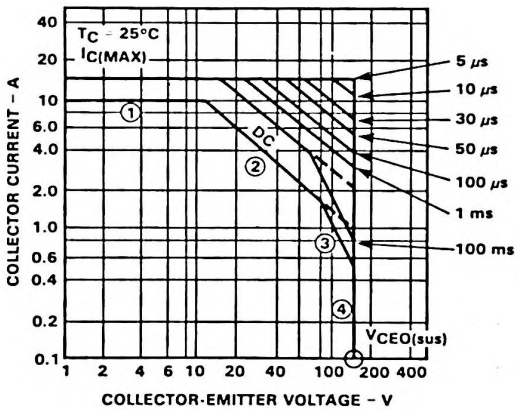


Fig. 2-1. Typical Safe Area

Thermal Limit (2 in Figure 2-1)
The maximum permissible power dissipation is determined by the maximum operating temperature of the transistor. In Figure 2-1, the case temperature T_C is constant, normally 25°C; therefore the power limitation is

$$P_D = \frac{T_{J(max)} - 25°C}{\theta_{JC}}$$

where $T_{J(max)}$ is maximum junction temperature.
θ_{JC} is junction-to-case thermal resistance.

Maximum operating temperature and thermal resistance can be found in the data sheets. $T_{J(max)}$ is normally 150°C for plastic transistors, 200°C for hermetic (metal can) types. If power is applied in excess of this limit, the transistor is not necessarily destroyed, but the mounting system of the die or the plastic can deteriorate. For power pulses, the limit is higher than for dc especially for short pulses due again to thermal capacitance.

I_{SB} Limit (3 in Figure 2-1)
At higher voltages, the SOA of the transistor is limited by its forward-biased second breakdown capability, I_{SB}. In this mode, current crowding occurs at the emitter periphery. The higher the operating voltage, the more the base is pinched and the sheet resistance increases. Accordingly, the V_{BE} on the edges of the emitter is higher than in the middle because the base current is pushed under the emitter (Figure 2-2). Therefore emitter-current density increases on the emitter edges. This leads to localized heating, which in turn lowers the V_{BE} characteristic causing more crowding. Localized thermal runaway (hotspot) may occur. The process of temperature build-up along the emitter periphery takes some time; therefore the SOA limits for pulses are higher than for dc.

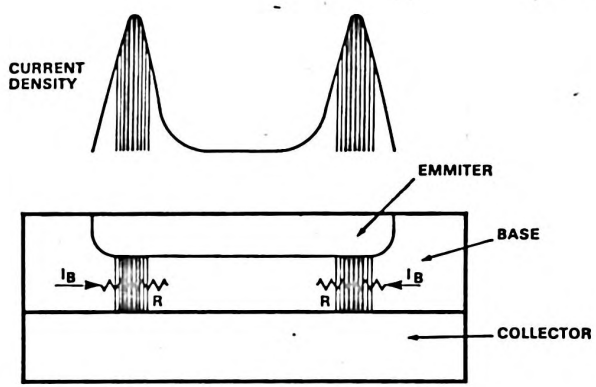
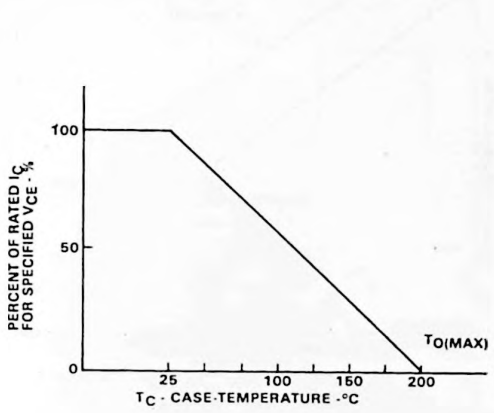


Fig. 2-2. Current Crowding During Forward-Biased Operation



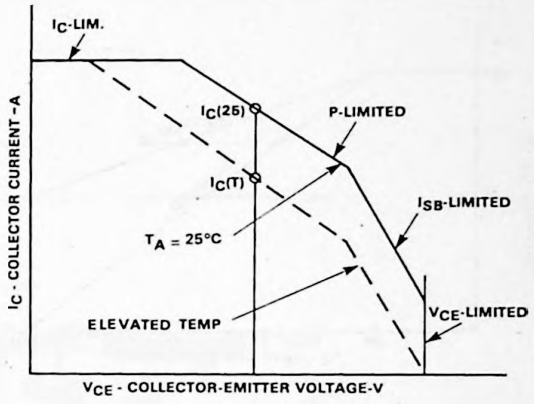


Fig. 2-3. Linear Temperature Derating to 200°C

Voltage Limit (4 in Figure 2-1)
The collector-emitter voltage V_{CE} should never surpass the maximum limit; not even a very short pulse is permissable. If this should happen, the collector current, which is governed by the circuit rather than the transistor, is likely to rise to a high value. This may destroy the transistor.

SOA at Elevated Temperature
Figure 2-1 shows the SOA for room temperature, i.e., the transistor case is at 25°C. A power transistor normally runs at a higher temperature and the data sheet specifies a derating factor. Figure 2-3 shows linear derating to 200°C. The permissable collector current must be derated as well as the power and I_{SB} - limited segments of the SOA curve and the dc and pulse curves. The maximum collector current is not derated and stays the same for all operating temperatures (I_C-limited part of SOA curve).

The formula for linear derating is

$$I_{C(T)} = I_{C(25°C)} \quad \frac{T_O - T}{T_O - 25°C}$$

$I_{C(25°C)}$ permissable I_C at 25°C

$I_{C(T)}$ permissable I_C at temperature T

T_O operating temperature, eg. 200°C in Figure 2-3

There are instances when the power-limited and the I_{SB}-limited parts of the SOA are derated differently. This is because the I_{SB} failure occurs at a localized hotspot of about 400°C. It should be noted in the example in Figure 2-4 that, in derating power and I_{SB}-limited parts of the SOA differently, the dotted part of the power-limit line must be used; the knee of the curve moves towards higher voltage. The pulse curves are temperature derated in the same manner as for dc.

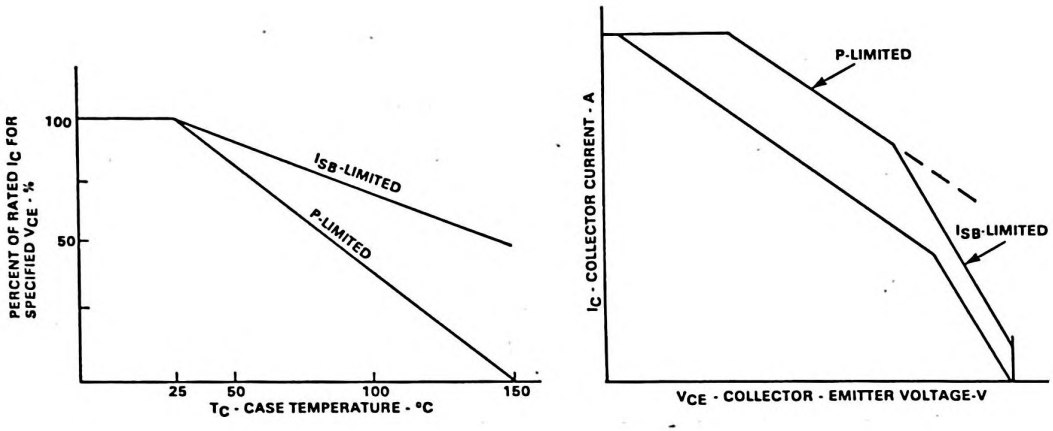


Fig. 2-4. Temperature Derating to Different Temperature for Power and I_{SB}-Limited SOA

PULSED SOA

Figure 2-1 shows pulsed SOA curves as well as dc SOA curves. They apply to a single pulse and to 25°C case temperature. The following procedure is used to determine whether or not a pulse train is safe.

- Find the average temperature of the die.

$$T_{J(avg)} = \frac{P_{avg}}{\theta_{JX}} + T_X$$

$$P_{avg} = \frac{1}{t}\int_t P(t)dt$$

where P_{avg} is the average dissipation of the transistor, T_X is the temperature of the area where T is constant, θ_{JX} is the thermal resistance from the junction to T_X; this may be the case, the heat sink or the ambient.

This average temperature is the result of all the dissipated power. Theoretically, this power can be eliminated by assuming a T_C equal to $T_{J(avg)}$. Now, one single pulse at $T_C = T_{J(avg)}$ can be evaluated to determine whether or not the whole pulse train is safe.

- Derate the SOA curves to $T_{J(avg)}$ and evaluate the single pulse.

This method is somewhat conservative, because the temperature immediately before the pulse is lower than the average temperature (Figure 2-5).

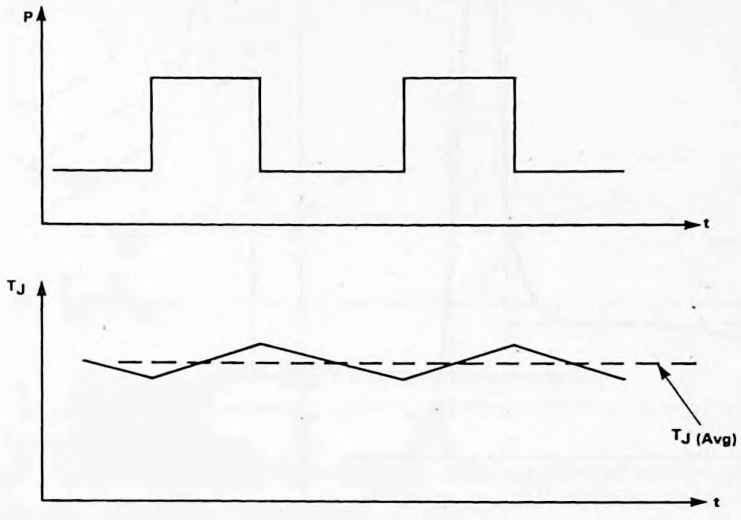


Fig. 2-5. Die Temperature During Pulse Train

Pulse Evaluation

Up to now, only square pulses have been considered. Precise handling of non-square pulses is difficult, but in most cases, good approximations can be achieved.

Example 1

If a pulse as shown in Figure 2-6 is evaluated, the best approximation is a square pulse (a). But, since there is no easy way to get this pulse, a pulse (b) that is as high as the maximum power and has the same area as the original pulse is used. If this pulse (b) is safe, then the original pulse is certainly safe.

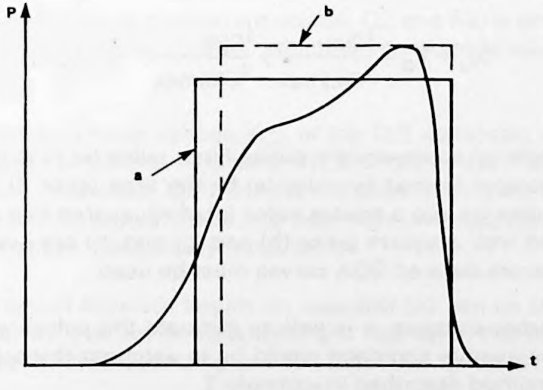


Fig. 2-6. Pulse Evaluation (Example 1)

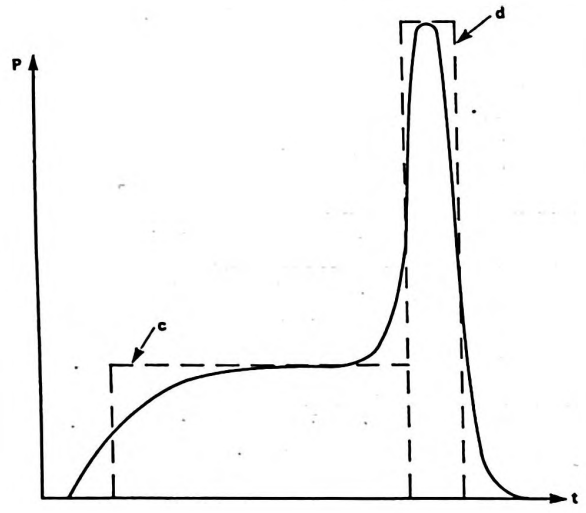


Fig. 2-7. Pulse Evaluation (Example 2)

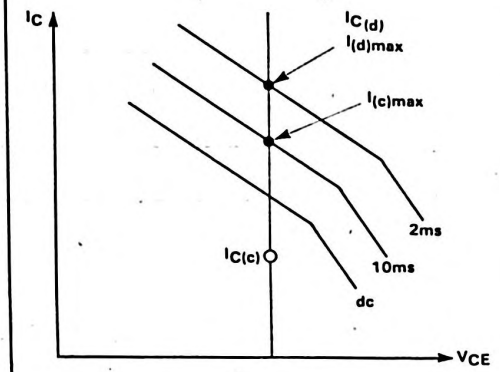


Fig. 2-8. SOA Diagram (Example 2)

Example 2

For a pulse as shown in Figure 2-7, the above method would be too stringent. In this example, the pulse is approximated by two square pulses dividing along the broken line; pulse (c) is evaluated first. In Figure 2-8, $I_{C(c)}$ is the collector current that pulse (c) carries, while $I_{C(c)max}$ is the capability of the transistor. The fraction of the transistor I_C capability used by this pulse, which is also the amount of localized heating that has occurred, is determined by a simple formula.

$$X_c = \frac{I_{C(c)}}{I_{C(c)max}}$$

The second pulse (d) is then evaluated in the same manner. The application is safe if the following condition can be met.

$$X_c + X_d = \frac{I_{C(c)}}{I_{C(c)max}} + \frac{I_{C(d)}}{I_{C(d)max}} \leqslant 100\ \%$$

Example 3

Figure 2-9 is another example of a non-square pulse. First, pulse (e) is evaluated using the method in example 1. Note that the hotspot formed by pulse (e) by the time pulse (f) starts; this is taken into account when transforming pulse (e) into a square pulse (g) of equal area that ends where pulse (f) begins. Pulse (f) is then transformed into a square pulse (h) and (g) and (h) are evaluated by the same method used in example 2. Temperature derated SOA curves must be used.

If the power occurs at different voltages, it is safe to evaluate the pulses as if they all occurred at the highest voltage. A less conservative approach would be to segment the pulses and evaluate each segment at its voltage by the method described in example 2.

Although this method is not exact, it results in a decision as to the safety of the pulse in most cases. An area exists in between where more exact methods or experiments must be used.

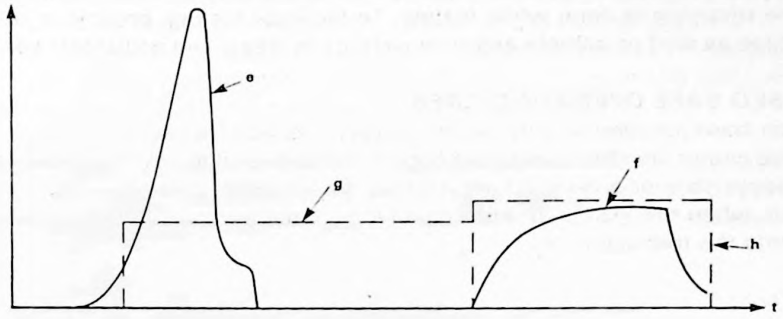


Fig. 2-9. Pulse Evaluation (Example 3)

TESTING OF FORWARD BIASED SOA

SOA testing is basically a destructive test. A power pulse, with a specified current, voltage and duration is applied to the transistor under test TUT. In case of failure, the TUT destroys itself. To avoid this, a protection circuit is used, to sense the failure and remove the power from the TUT. Protection time is different for each transistor; 25 μs may be satisfactory for a slow, rugged device, while a fast transistor, specially when tested at high voltage, needs 1 μs or less.

The basic circuit of the test set should provide reasonable accuracy; 5% accuracy in a working test set is better than 0.1% in one prone to false triggering, 1-2% is probably a happy medium. It should be able to apply the power pulse quickly for testing pulsed SOA (50-100 μs settling time gives a 1 ms test capability). The power pulse should not cause ringing, that is apt to trigger the protection circuit. A test set must be capable of testing a variety of power transistors having different f_Ts.

The simple I_{SB} test set in Figure 2-10 operates up to 1 A and 300 V. The TUT is in series with a current source, Q2, Q1 and associated circuitry. I_C is set by the 250 Ω pot. The TUT base current is supplied by a 20V Zener diode D1 and is effectively in a common-base mode. This makes the circuit very stable since it takes the beta of the TUT out of the feedback loop. The test voltage is set by the main power supply which must be set 20V higher than V_{CE} since the Zener D1 pulls the base up 20V.

The timing pulse switches the TUT while the current source, Q2 and R2, is primed all the time. This holds point A low at all times, especially during turn-on, which is important to avoid "false triggering" of the protection circuit.

When the TUT fails, the collector-emitter voltage V_{CE} of the TUT collapses, and point A goes positive in respect to the reference voltage at point B. The differential amplifier Q4 - Q5 flips over, turning Q5 on, which in turn switches Q3 on. Transistor Q3 removes the base drive from the pass transistor Q2, and the current through the TUT is interrupted. Point A is held high and thus the protection circuit is latched until it is reset by the button which temporarily turns Q4 on.

The speed of the protection circuit depends largely on how fast Q2 can be switched off. Since Q2 operates with a V_{CE} of about 10 V, it is not in saturation and has very little storage time. Also, the base charge is actively removed by Q3 thus providing low fall time.

The pass transistor Q2 and its 10 Ω emitter resistor dissipates a maximum of 10W each. In a test set, it is good practice to design the circuit for double the dissipation. The diodes are used for slight level shifts and essentially trim threshold of the protection circuit to an optimum value.

To operate the tester, first set I_C, preferably at reduced collector voltage to reduce dissipation during repeated testing. Next, set the collector voltage by setting the supply voltage about 10V above the desired V_{CE}. The fine trimming is done while testing. To facilitate testing, provisions could be added to set current and voltage as well as sample and hold circuitry to freeze the actual test values.

REVERSE-BIASED SAFE OPERATING AREA

When the emitter-base junction of a transistor is reverse biased, the device begins to turn off. In an unclamped inductive circuit, an electrical stress occurs that can result in reverse-biased second breakdown. When the load is resistive or a clamped inductance, the transistor sees very little energy in the reverse-biased mode; but, when the load is an unclamped inductance, almost all of the energy contained in the coil is dumped into the transistor, *i.e.*,

$$E = 1/2\ LI_C^2$$

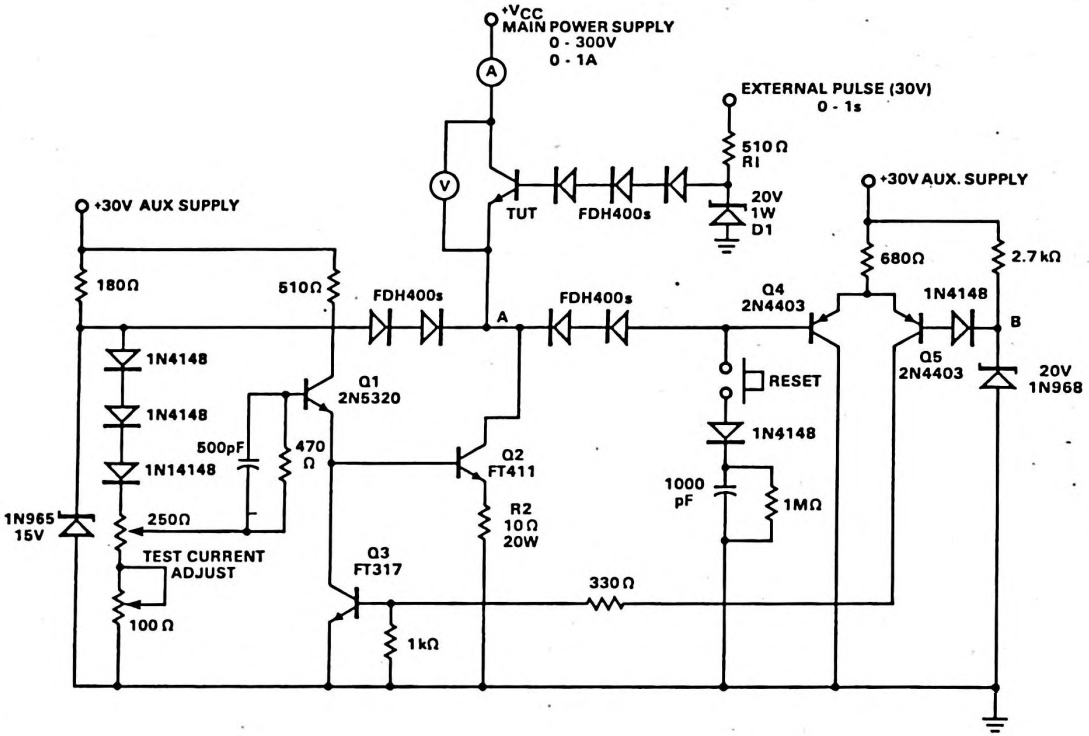


Fig. 2-10 Fairchild Power 300V 1A I_{SB} Tester

Second breakdown energy E_{SB} is the guaranteed reverse-biased energy the transistor is capable of withstanding. When the emitter-base junction is reverse biased, a transverse voltage gradient appears in the base region forcing severe current crowding under the center of the emitter (*Figure 2-11*). This condition is further aggravated by thermal feedback. If the energy in this hot spot raises the temperature of the silicon above approximately 400°C, the emitter-base junction goes into avalanche and the sustaining voltage collapses within nanoseconds. Usually, the transistor is destroyed.

During reverse-bias operation, current is concentrated in a small centralized area rather than in a relatively larger area under the emitter periphery as is the case during forward-biased operation. Therefore, since the current crowding is greater, E_{SB} is much less than the energy capability when the transistor is forward biased.

The E_{SB} capability of a power transistor depends on both the transistor and the circuit design. For low E_{SB} stress, the transistor design must include a large emitter area, a high resistive collector and graded collector doping to reduce current crowding. The circuit should be designed with low inductance (*Figure 2-12*) and low I_C to maintain low energy, keeping in mind that for a specified energy level, as L increases, second breakdown stress on the transistor becomes more severe. To reduce the transverse voltage gradient in the base, and therefore reduce current crowding, low reverse bias V_{BE} and large base resistance R_{BE} are required.

The effective capacitance C_{eff} on the collector should be low, otherwise it takes too long for the C_{eff} to charge to $V_{CE(sus)}$ and the device turns off completely (curve 3a in *Figure 2-13*). When this happens, the voltage rises to the blocking voltage and the C_{eff} discharges into the transistor (snap back). This is a very stressing situation since the collector current goes high during total cutoff thus causing extreme current crowding. Generally, an E_{SB} stress is safe as long as the dissipated energy is less than that specified on the data sheet and provided $L \leq L_{spec}$, $R_{BE} \geq R_{BE(spec)}$, $|V_{BE}| < |V_{BE(spec)}|$, and the device is operated in the sustaining mode and snapback is avoided by holding C_{eff} low (See *Figure 2-14*). When $L > L_{spec}$, the SOA limit follows an approximate curve, LI_C^{ϑ} = constant; it is usually safe to consider $\vartheta = 1$.

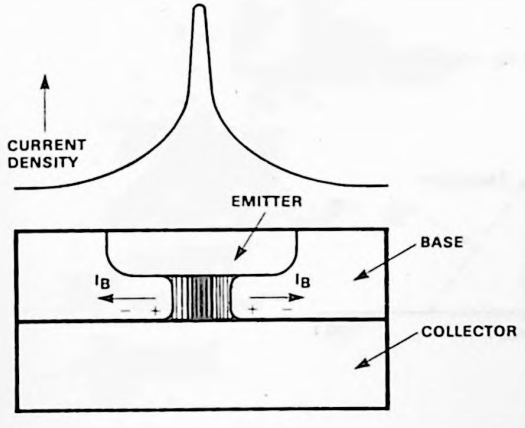


Fig. 2-11. Current Crowding During Reverse-Biased Cutoff

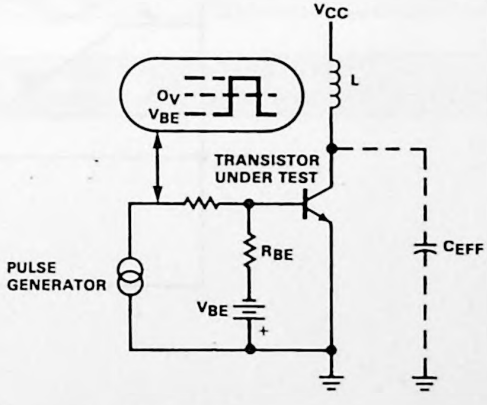
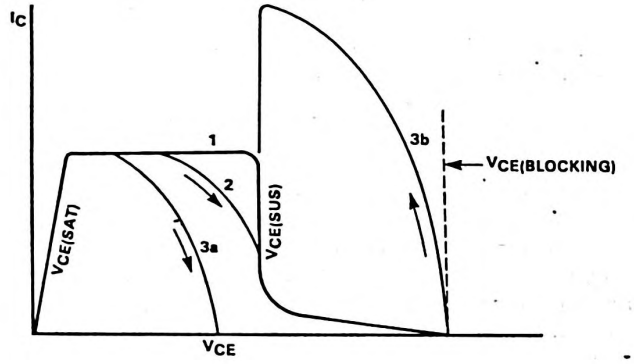


Fig. 2-12. Reverse-Biased Transistor with Inductive Load



NOTES:
Curve 1: Turn off with very small C_{eff}
Curve 2: C_{eff} softens the curve; it must be charged before $V_{CE(sus)}$ is reached.
Curve 3: Large C_{eff} allows the transistor to turn off (3a) before the energy stored in L is discharged. Snap back occurs at 3b.

Fig. 2-13. Inductive Turn Off

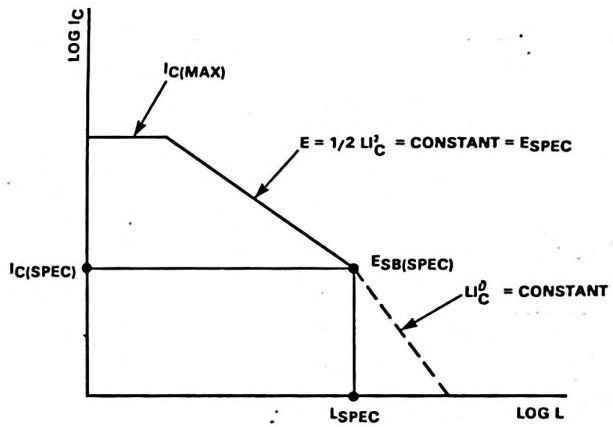
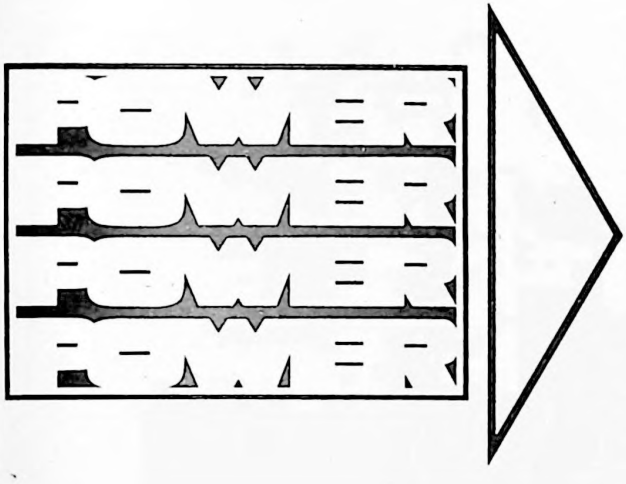


Fig. 2-14. Reverse-Biased Safe-Operating Area

Although this is a valid rating system, it is good design practice to avoid reverse-biased stress by clamping or waveshaping. While the power-transistor manufacturer can guarantee an E_{SB} rating, it must be kept in mind that non-destructive testing is difficult, lot-to-lot and unit-to-unit variations are significant and the fast high voltage power transistors, in particular, have limited E_{SB} capabilities.



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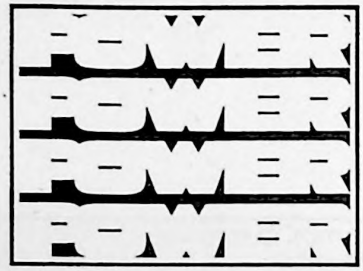
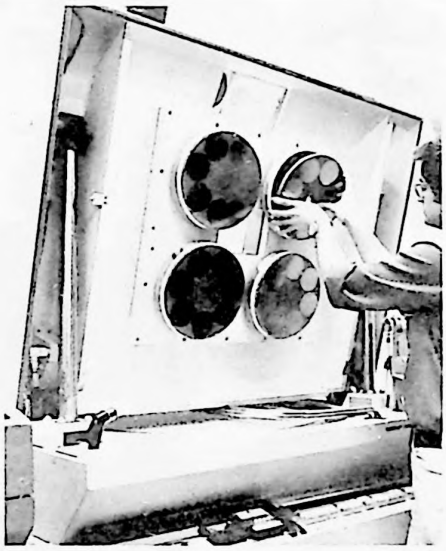


CHAPTER 3

Chapter 3
MANUFACTURING

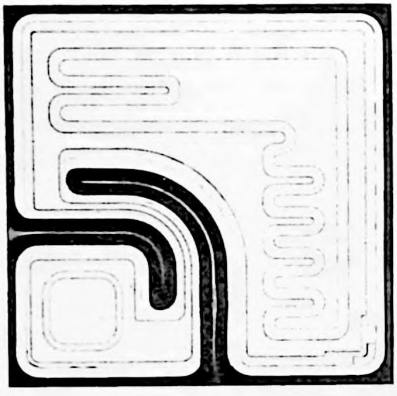
Modern equipment plus state-of-the art technology enables Fairchild to build competitive high reliability, high volume power devices. Important stages of manufacture are illustrated. The Fairchild Power Group does not depend upon outside sources for critical materials or processing.

Crystal Puller



Lapping

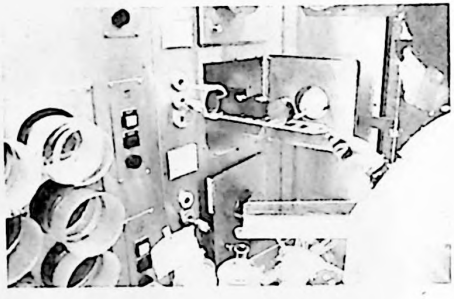
Epi Reactor



Mask

Photo Mask Alignment

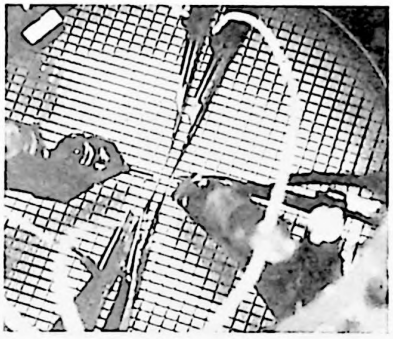
Etching



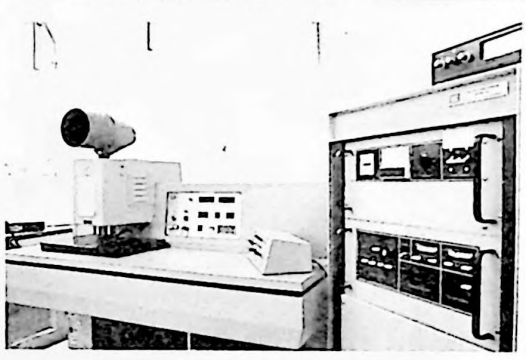
Automatic Diffusion Furnace

Wafers Mounted for Evaporator

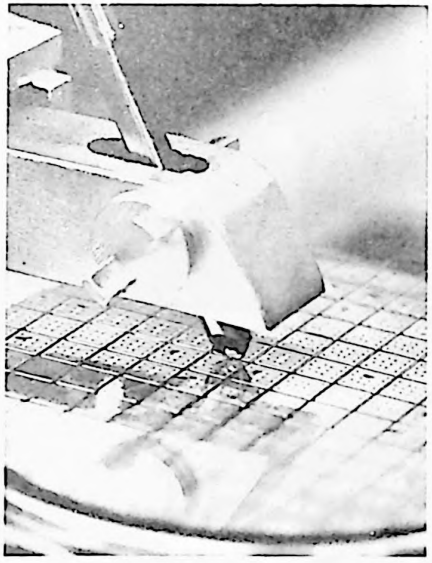
Completed Wafers Ready for Assembly



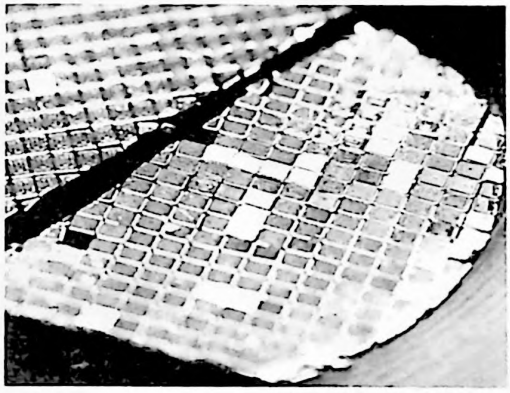
Probing the Die



Laser Scriber

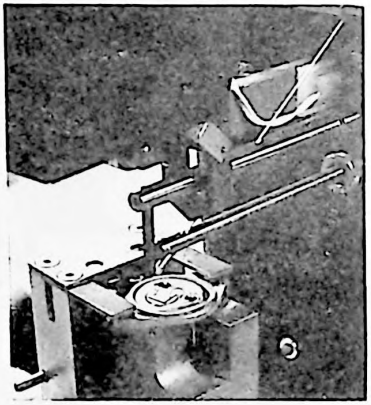


Diamond Scribing

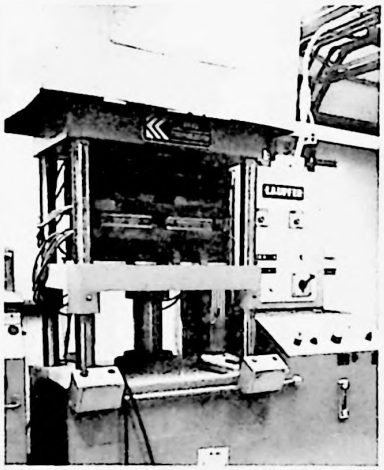


Broken Wafer

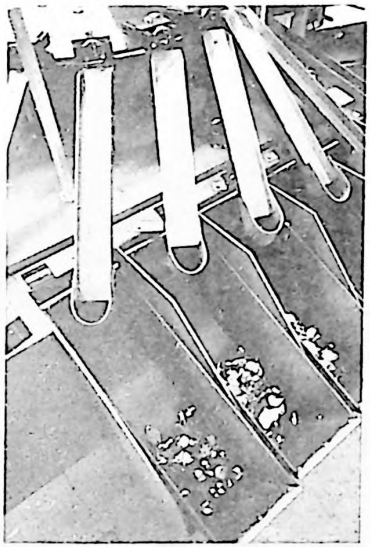
TO-220/TO-3 Die Attach Furnace



Heavy Duty Stitch Bonder

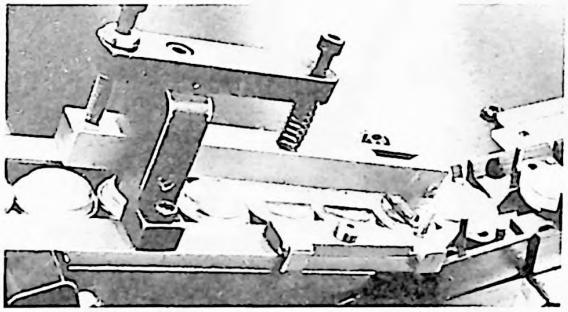


TO-220 Plastic Mold

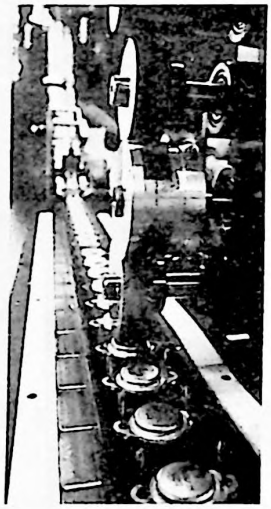


TO-3 Tester

TO-39 Lead Straightener

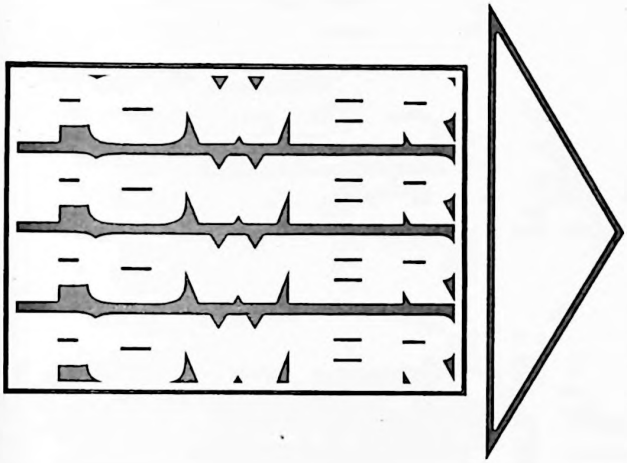


Automated TO-3 Handling



Marker and Drier

Automatic Tray Pack



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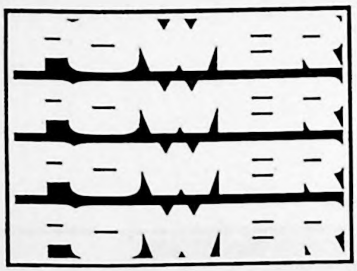


CHAPTER 4

- Thermal Resistance
- Heat Sinking
- Mounting Techniques
- TO-220 Lead Bending
- Tips for Better Heat Sinking

Chapter 4
POWER TRANSISTOR PACKAGING AND HEAT SINKING

Fairchild offers a wide variety of power packages to fill every power-transistor requirement (*Figure 4-1*). For low and medium power applications, the TO-39 and TO-66 hermetic packages are available. Their sturdy construction ensures high reliability in virtually any environment. For high power and high reliability requirements, a wide range of dice is provided in the TO-3 package. The plastic TO-220 gives the best trade-off between cost and reliability and can be confidently designed into applications where cost is a major factor.

After the designer has considered all the power-transistor requirements based on maximum ratings, reliability, cost and design dimensions, he reaches the point where a decision must be made on package. Usually, more than one will meet the power requirement.

THERMAL RESISTANCE

The most useful design tool is thermal resistance. This figure of merit is an electrical analogy of the heat flow from the transistor junction. *Figure 4-2* shows a simplified equivalent circuit for a typical semiconductor device in equilibrium. The power dissipation, which is analogous to current flow in electrical terms, is caused by a heat source similar to a voltage source. Temperature is analogous to voltage potential and thermal resistance to ohmic resistance. Extending the analogy of Ohm's law to *Figure 4-2*.

$$\theta_{JA(tot)} = \theta_{JC} + \theta_{CS} + \theta_{SA} = \frac{T_J - T_A}{P_D}$$

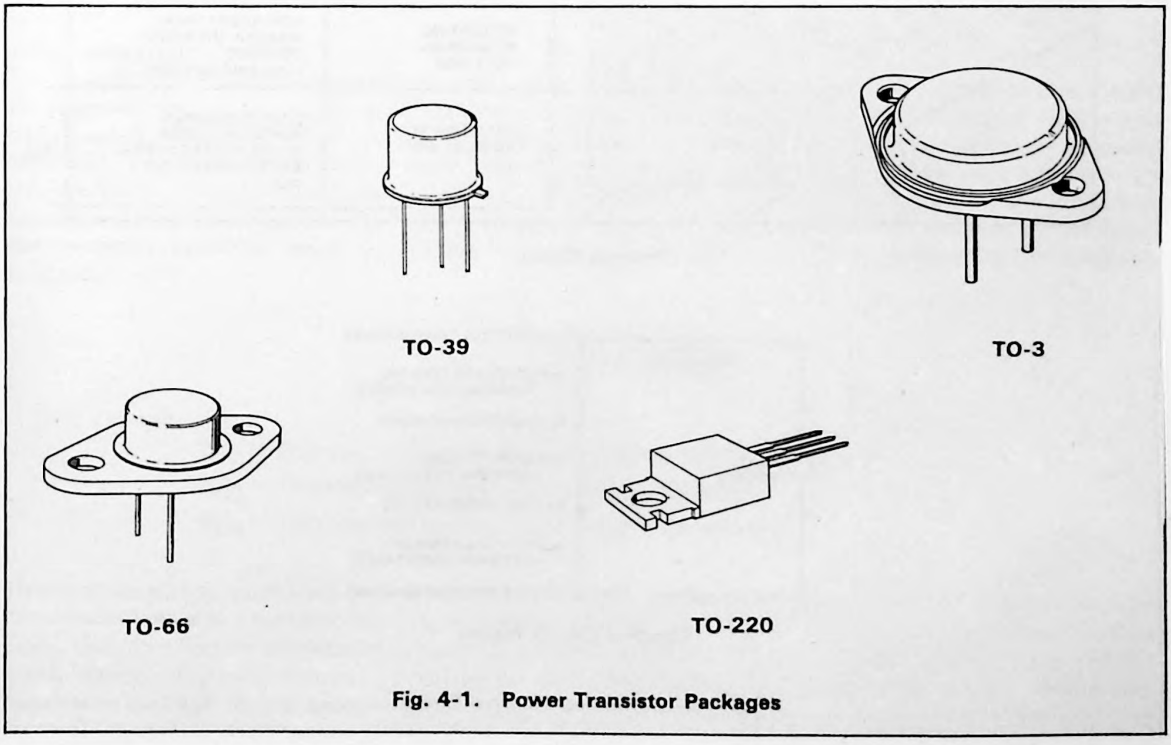
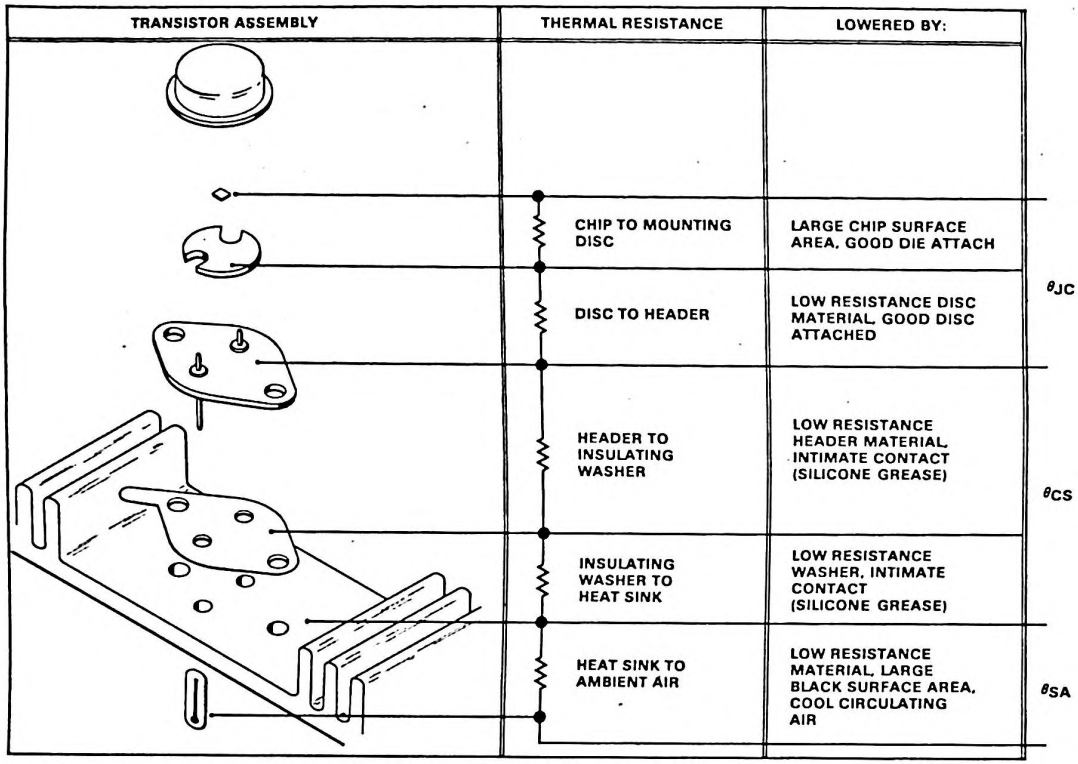
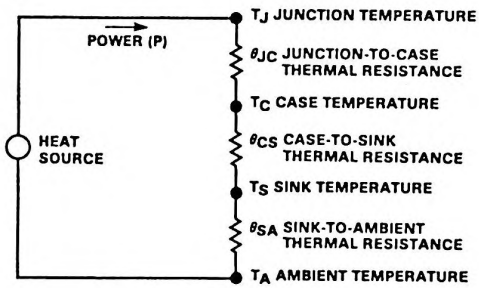


Fig. 4-1. Power Transistor Packages

Thermal resistance, then, is the rise in the temperature of a package above some reference level per unit of power dissipation in that package, usually expressed in degrees centigrade per watt. The reference temperature may be ambient or it may be the temperature of a heat sink to which the package is connected. There are several factors that affect thermal resistance including die size, the size of the heat source on the die, die-attach material and thickness, leadframe material, construction and thickness.



Thermal Circuit



Thermal Circuit Model

Fig. 4-2 Simplified Thermal Circuit

PACKAGE	θ_{JC} (°C/W)	θ_{CA} (°C/W)
TO-5/39	25 – 40	150
TO-220	1.5 – 3.0	70
TO-66	5 – 15	66
TO-3	0.8 – 6	30

Table 4-1. Thermal Resistance Ranges Junction to Case

Some typical values of junction-to-case thermal resistance θ_{JC} for different packages are shown in *Table 4-1*. Note that many packages have overlapping thermal resistance values. There are limitations to the thermal resistance model because junction temperature is never spatially uniform and there is no unique value that can be defined for all operating conditions; therefore, the model must be used for a first approximation. The manufacturer's safe operating area curves must be referenced for secondary breakdown limitations and pulsed characteristics.

In general, a reliable design has the lowest calculated junction temperature, therefore it is good practice to make a decision based on the calculated temperature for a package. The choice can be made between using a small package at a high junction temperature versus a larger package at a lower temperature. There is an obvious trade off between cost and reliability. In many applications, plastic power transistors can be used to accomplish the best trade off. Plastic power transistors are less expensive because of the strip assembly which lends itself more readily to automated assembly. As die costs continue to improve, the package becomes a higher percentage of the total device cost. With plastic power devices, the designer can achieve the minimum cost per watt. Their small size make them particularly good for designs that require high peak power for a relatively small amount of space.

HEAT SINKING

The failure rate of silicon semiconductors decreases approximately one order of magnitude for every 40°C decrease in junction temperature. Therefore, transistor mounting and heat sinking is critical for the best utilization of the power transistor. In general two types of commercial heat sinks are used, the extruded type with a specified thermal resistance and the clip-on heat sink. Thermal resistance information on commercially available heat sinks is normally provided by the heat sink manufacturer; a summary is shown in *Table 4-2*. Once the heat sink thermal resistance is known, then for any ambient temperature, the maximum available power dissipation for a particular device may be calculated using the following formula.

$$P_{D(max)} = \frac{T_{J(max)} - T_{A(max)}}{\theta_{JC} + \theta_{CS} + \theta_{SA}}$$

where:

θ_{JC} = Thermal resistance from junction to case.

θ_{CS} = Thermal resistance from case to heat sink.

θ_{SA} = Thermal resistance from heat sink to ambient.

Thermal resistance decreases as the thickness of the mounting material increases. The θ_{CS} varies with the device-heat-sink interface—the use or absence of a zinc-filled silicone grease to help remove surface voids, the inclusion or absence of an electrical isolating mica, beryllia, or anodized aluminum washer, and finally the degree of mounting pressure which is applied through the device hold-down mechanism. Applicable package torque specifications should be observed to further minimize the case-to-heat sink thermal resistance. A comparison of thermal resistances θ_{CS} for various mounting techniques is given in

Table 4-3. The maximum power dissipation capability of a device can be calculated for the following electrical and thermal conditions:

Power device	2N3055
Maximum ambient temperature	65°C
Heat sink thermal resistance*	2.5°C/W at 10 W
Mica washer with silicone grease**	0.4°C/W
θ_{JC} (from data sheet)	1.5°C/W

*Thermal resistance decreases slightly with increasing power dissipation.
**Silicone grease applied to both sides of washer.

This list is only representative. No attempt has been made to provide a complete list of all heat sink manufacturers. All values are typical as given by manufacturer or as determined from characteristic curves supplied by manufacturer.

θ_{SA} Approx. (°C/W)	Manufacturer and Type
	TO-3 Packages
0.4 (9" length)	Thermalloy (Extruded) 6590 Series
0.4 — 0.5 (6" length)	Thermalloy (Extruded) 6660, 6560 Series
0.56 — 3.0	Wakefield 400 Series
0.6 (7.5" length)	Thermalloy (Extruded) 6470 Series
0.7 — 1.2 (5 — 5.5" length)	Thermalloy (Extruded) 6423, 6443, 6441, 6450 Series
1.0 — 5.4 (3" length)	Thermalloy (Extruded) 6427, 6500, 6123, 6401, 6403, 6421, 6463, 6176, 6129, 6141, 6169, 6135, 6442 Series
1.9	IERC E2 Series (Extruded)
2.1	IERC E1, E3 Series (Extruded)
2.3 — 4.7	Wakefield 600 Series
4.2	IERC HP3 Series
4.5	Staver V3-5-2
4.8 — 7.5	Thermalloy 6001 Series
5 — 6	IERC HP3 Series
5 — 10	Thermalloy 6013 Series
5.6	Staver V3-3-2
5.9 — 10	Wakefield 680 Series
6	Wakefield 390 Series
6.4	Staver V3-7-224
6.5 — 7.5	IERC UP Series
8	Staver V1-5
8.1	Staver V3-5
8.8	Staver V3-7-96
9.5	Staver V3-3
9.5 — 10.5	IERC LA Series
9.8 — 13.9	Wakefield 630 Series
10	Staver V1-3
11	Thermalloy 6103, 6117 Series
	TO-220 Packages *
4.2	IERC HP3 Series
5 — 6	IERC HP1 Series
6.4	Staver V3-7-225
6.5 — 7.5	IERC VP Series
7.1	Thermalloy 6070 Series
8.1	Staver V3-5
	TO-220 Packages *
8.8	Staver V3-7-96
9.5	Staver V3-3
10	Thermalloy 6032, 6034 Series
12.5 — 14.2	Staver V4-3-192
13	Staver V5-1
15	Thermalloy 6030 Series
15.1 — 17.2	Staver V4-3-128
16	Thermalloy 6072, 6106 Series
18	Thermalloy 6038, 6107 Series
19	IERC PB Series
20	Staver V6-2
20	Thermalloy 6025 Series
25	IERC PA Series
	TO-5 and TO-39 Packages
12	Thermalloy 1101, 1103 Series
12 — 16	Wakefield 260-5 Series
15	Staver V3A-5
22	Thermalloy 1116, 1121, 1123 Series
22	Thermalloy 1130, 1131, 1132 Series
24	Staver F5-5C
25	Thermalloy 2227 Series
26 — 30	IERC Thermal Links
27 — 83	Wakefield 200 Series
28	Staver F5-5B
34	Thermalloy 2228 Series
35	IERC Clip Mount Thermal Link
39	Thermalloy 2215 Series
41	Thermalloy 2205 Series
42	Staver F5-5A
42 — 65	Wakefield 296 Series
46	Staver F6-5, F6-5L
50	Thermalloy 2225 Series
50 — 55	IERC Fan Tops
53	Thermalloy 2211 Series
55	Thermalloy 2210 Series
56	Thermalloy 1129 Series
58	Thermalloy 2230, 2235 Series
60	Thermalloy 2226 Series
68	Staver F1-5
72	Thermalloy 1115 Series

* Most TO-3 heat sinks can also be used with TO-220 packages with appropriate hole patterns.

IERC 135 W Magnolia Blvd., Burbank, CA 91502
Staver Co. Inc 41-51 N Saxon Ave., Bay Shore, N Y 11706
Thermalloy Inc. 2021 W Valley View Lane, Dallas, TX 75234
Wakefield Engineering, Inc.: Audubon Rd., Wakefield, MA 01880

Table 4-2. Heat Sink Selection Guide

PACKAGE	METAL TO METAL		INSULATOR	
	DRY	COMPOUND	DRY	COMPOUND
TO-220	1.2 – 2.0	0.6 – 1.2	–	2.1 – 2.6
TO-66	0.8 – 1.5	0.4 – 0.9	–	1.4 – 1.7
TO-3	0.05 – 0.2	0.005 – 0.10	0.55 – 0.8	0.28 – 0.40

Table 4-3. Thermal Resistance Case to Heat Sink

Maximum power dissipation is:

$$P_{D(max)} = \frac{200°C - 65°C}{1.5 + 0.4 + 2.5} = \frac{135}{4.4} = 30.7\ W$$

Similarly, if the heat sink thermal resistance is required for the following conditions:

$\theta_{JC} = 3°C/W$ $\quad T_{A(max)} = 55°C$

$T_{J(max)} = 200°C$ $\quad P_D = 15\ W$

Anodized aluminum washer with silicone grease

then:

$$\theta_{SA} = \frac{T_{J(max)} - T_A}{P_D} - (\theta_{JC} + \theta_{CS}) = \frac{200 - 55}{15} - (3 + 0.3) = 9.7 - 3.3 = 6.4°C/W$$

For TO-39 devices, mechanically mounted, *i.e.,* without heat sinks, case-to-ambient thermal resistance, θ_{CA}, must be considered. This resistance is typically much greater than θ_{JC} since the mode of heat transfer is by convection and radiation into the surrounding ambient air, rather than by direct conduction. The total resistance to heat transfer out of the chip is the sum of θ_{JA} and θ_{CA}. The sum is junction-to-ambient thermal resistance θ_{JA}. A typical value for a TO-39 device is 175°C/W.

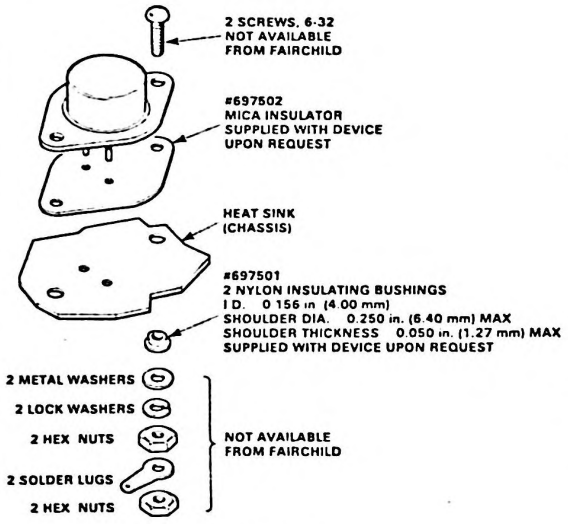
MOUNTING TECHNIQUES

To take full advantage of the power handling capability of power transistors, it is imperative to follow proper mounting procedures – preparation of the mounting surface, application of a thermal compound and use of correct fastening techniques.

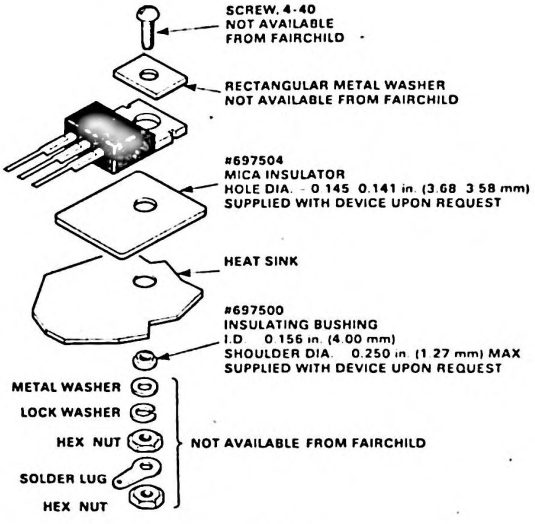
In general, the package should be as flat and smooth as the transistor die. For low-power applications, the heat-sink surface is satisfactory if it is flat when held against a straightedge and there are no deep scratches. For high-power applications, a more stringent examination of the surface is required.

Most commercially available heat sinks require spotfacing. Generally, milled or machined surfaces are satisfactory. Furthermore, the surface must be free from all foreign material, film and oxide. Freshly bared aluminum forms an oxide layer in a few seconds. If the heat sink is not used immediately after machining, the mounting area should be polished with No. 000 steel wool and rinsed with alcohol or acetone. This is followed immediately with thermal grease.

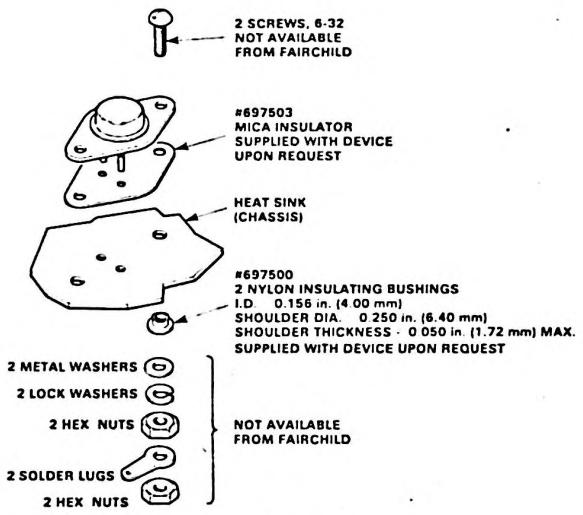
Thermal joint compounds are used to fill air voids between mating surfaces to improve contacts. They are a formulation of fine zinc particles in a silicone oil that maintains a grease-like consistency with temperature and time. The compounds are applied in a very thin coat with a spatula or lintless brush and wiped lightly to remove excess material. Or, a minimal amount may be placed around the center of the contact area; during mounting, rotation and pressure forces the compound over the contact area. Excess compound can be removed with acetone or alcohol. For good thermal conduction use a joint lubricant such as Dow Corning DC-340, General Electric 662 or Thermacote by Thermalloy.



TO-3



TO-220



TO-66

Fig. 4-3. Mounting Hardware

In some applications, it is desirable to electrically insulate the regulator case from the heat sink. Hardware kits for this purpose are commercially available for such packages as the TO-3 and TO-220. They generally consist of a 0.003 to 0.005 inch thick piece of mica or bonded fiberglass to electrically isolate the two surfaces, yet provide a thermal path between them. As expected, the thermal resistance will increase but, as in the direct metal-to-metal joint, some improvement can be realized by using thermal lubricant on each side of the mica.

TO-3 and TO-66

TO-3 and TO-66 packages are mounted as shown in *Figure 4-3*. When tightening the nuts, the screw threads should be free of grease to prevent inconsistent torque readings. Maximum allowable torque should be used to reduce θ_{CS}; torque ratings of the parts should never be exceeded.

TO-220 (Figures 4-3 and 4-4)

The TO-220 devices can be mounted by bolting, soldering, riveting or clamping. Each method has advantages and disadvantages. Choose the best method for the application. For small-volume applications, either bolting or clamping is the most practical because less investment in equipment is required. For larger volume applications, direct solder or riveting could be more economical. Regardless of method, the following precautions should be observed.

The plastic TO-220 package cannot be subjected to mechanical shock.

Mounting holes must not be oversized.

Proper hardware should be used (see *Figure 4-3*).

Spacers, insulators and washers should be resistent to cold flow under pressure.

Chassis or heat sink should fit smoothly in the mounting area.

A thermal compound should be used on all unsoldered interfaces between the device and the heat sink.

Bolting

The mounting holes in the TO-220 package are clearance holes for a 4-40 screw, however, a small head diameter screw is required to avoid damage to the plastic package. If a nylon shoulder washer such as FSC part #697500 is used, a 4-40 screw can be used. An 8 in. lb maximum torque on the mounting screw is sufficient to insure good thermal contact. Do not exceed this pressure or damage to the device may occur. Also do not allow the screw or screwdriver to contact the plastic package. Damage to the plastic package generally indicates damage to the device.

Clamping

TO-220 devices may be attached to heat sinks using spring clamps to apply spring pressure on the tab. These spring-clamp heat sinks are currently available from several manufacturers.

Soldering

The leads and tabs of the TO-220 package may be soldered. The leads should be soldered no closer than 0.065" to the plastic package at a maximum temperature of 260°C for 10 seconds or less. The heat-sink tabs can be soldered using a hot plate or tunnel oven at a maximum temperature of 225°C for 25 seconds. To solder successfully, parts must be cleaned with a solvent such as acetone, freon or alcohol, if necessary. Rosin flux may be used to improve solderability; acid or activated flux are not recommended.

Riveting

In large-volume operations, riveting is often desirable. The TO-200 has been mounted in large volume using an 1/8-inch brass eyelet rivet. The unit is clinched using an air-operated setting machine. The machine should be adjusted so the force applied (250 lb max) is just sufficient to achieve a good, tight fit without deforming the heat sink or the device tab.

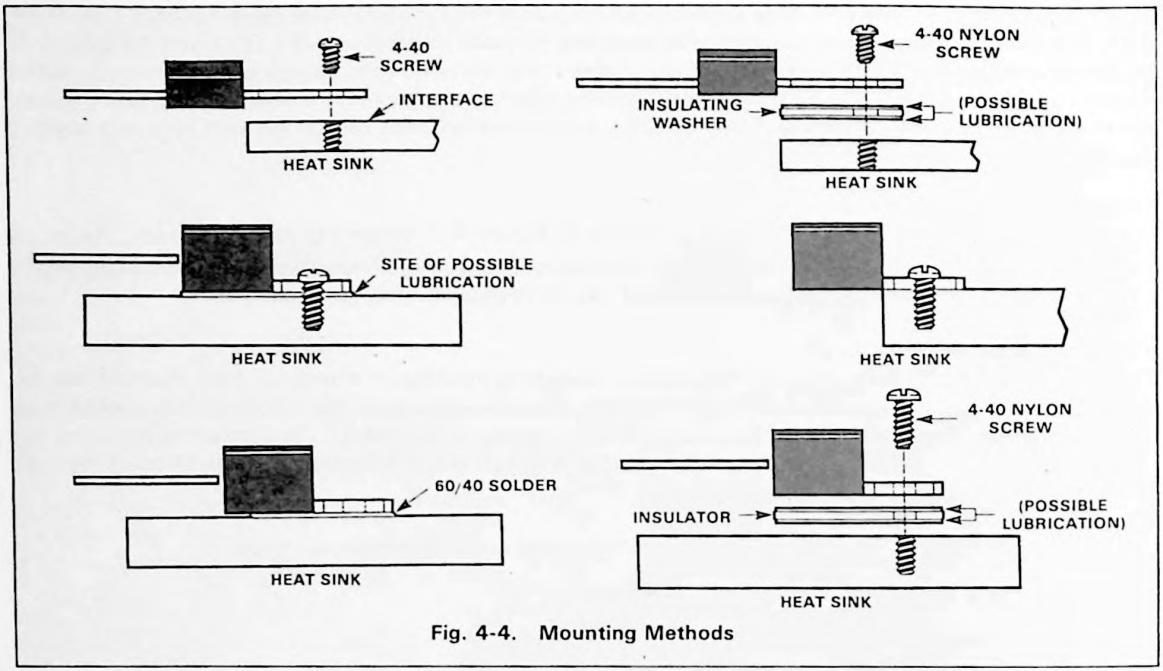


Fig. 4-4. Mounting Methods

TO-220 LEAD BENDING

Fairchild offers nine standard lead-bend variations (*Figure 4-5*). Special lead bends are available for a nominal tooling cost. The TO-220 leads are designed to allow a moderate amount of twisting and pulling and can withstand a maximum tension of six pounds during forming and assembly. The tension limit is only for circuit assembly. Strain relief should be provided if the unit is to be subjected to lead tension over a long period. Within limits, the leads may also be twisted. However, the leads must be firmly supported between the case and the twist and the twist should not exceed 90° in either direction. Avoid repeated bending and twisting since metal fatigue may occur and cause broken leads. Fairchild bends leads mechanically using special tooling. Leads may be hand formed using needle-nosed pliers; however, the leads must be clamped at a point between the plastic package and the bend to protect the package. The TO-220 device fits the same socket as the TO-66 and can be used as a direct replacement. The collector lead is trimmed and the emitter and base leads are formed as shown in *Figure 4-5* (TO-220-02).

TIPS FOR BETTER HEAT SINKING

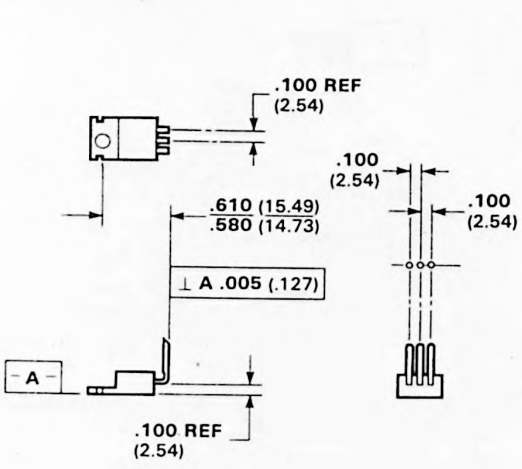
When using low dissipation packages such as TO-5 and TO-39, keep lead lengths to a minimum and use the largest possible area of the printed board traces or mounting hardware to provide a heat dissipation path.

When using larger packages, be sure the heat sink surface is flat and free from ridges or high spots. Check the package for burrs or peened-over corners. Regardless of the smoothness and flatness of the package and heat-sink contact, air pockets between them are unavoidable unless a lubricant is used. Therefore, for good thermal conduction, use a thin layer of thermal lubricant.

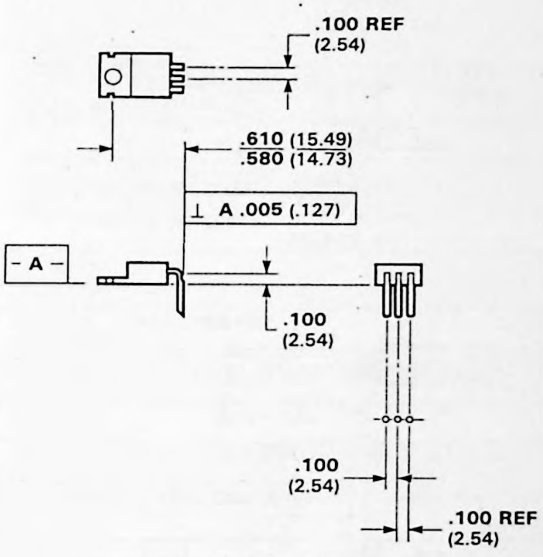
If it is necessary to electrically insulate the case from the heat sink, use available hardware kits that usually consist of a thin piece of mica or bonded fiberglass to electrically isolate the two surfaces.

If the device is mounted on a heat sink with fins, the most efficient heat transfer takes place when the fin is in a vertical plane, as this type of mounting forces the heat transfer from fin to air in a combination of radiation and convection.

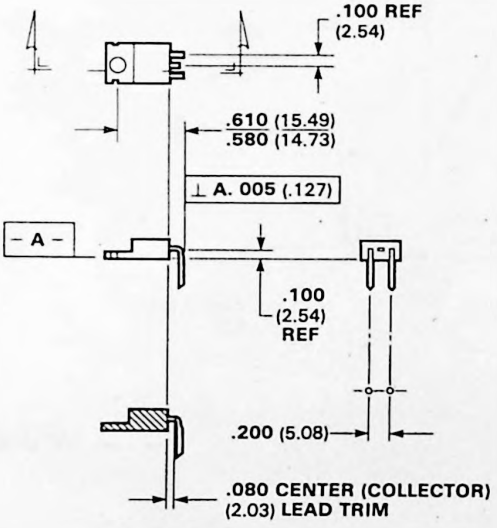
If it is necessary to bend any of the leads, handle them carefully to avoid straining the package. Furthermore, lead bending should be restricted since repeated bending will fatigue and eventually break the leads.



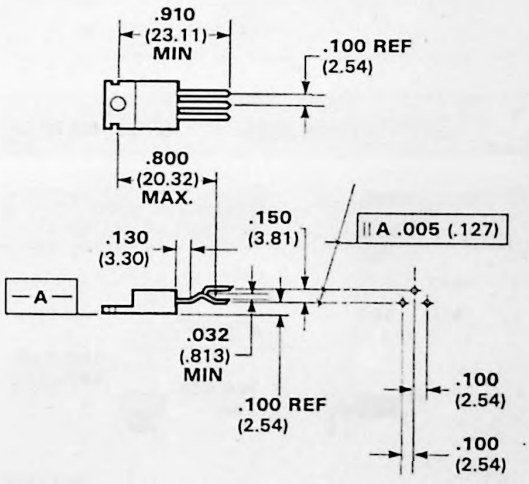
TO-220-01



TO-220-02



TO-220-03



TO-220-04

Fig. 4-5. TO-220 Standard Lead Bends

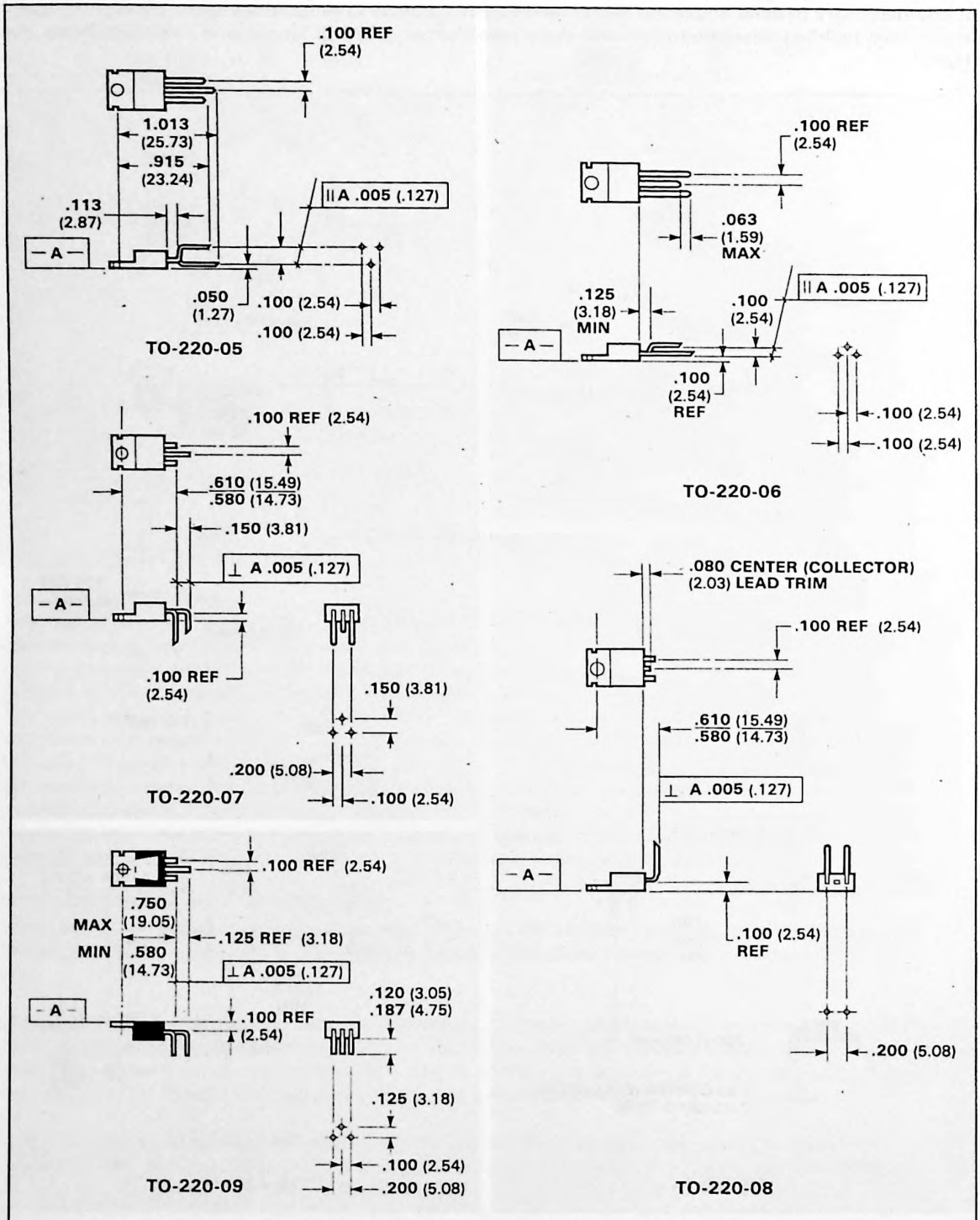
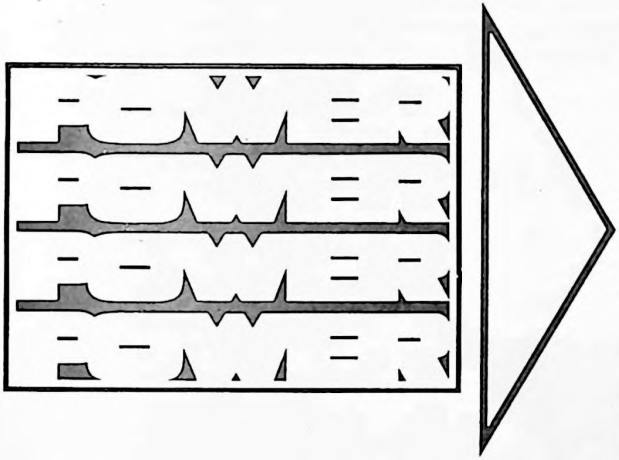


Fig. 4-5. TO-220 Standard Lead Bends (Cont'd)



DEVICE SELECTION GUIDES AND CROSS REFERENCE

POWER TRANSISTOR TECHNOLOGY 1

SAFE OPERATING AREA 2

POWER TRANSISTOR MANUFACTURING 3

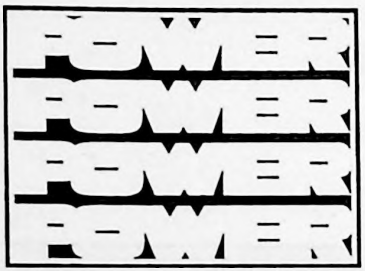
POWER TRANSISTOR PACKAGING AND HEAT SINKING 4

POWER TRANSISTOR RELIABILITY 5

PRODUCT INFORMATION 6

DEFINITIONS OF SYMBOLS AND TERMS 7

FAIRCHILD FIELD SALES OFFICES, SALES REPRESENTATIVES, DISTRIBUTOR LOCATIONS 8



CHAPTER 5

- Areas of Consideration
- Wafer Manufacture
- Failure Analysis
- Reliability Monitor and Control
- JAN Power Devices

Chapter 5
POWER TRANSISTOR RELIABILITY

INTRODUCTION

There are three basic ingredients in the manufacture of reliable power transistors. First, the device must be designed with the user's applications and reliability requirements in mind. Secondly, the device must be manufactured with the optimum technology for the application. Thirdly, controls must be established to assure maintenance of the quality/reliability levels established in the design of the device. Consideration is given to the reliability influence of each part of the manufacturing and testing cycle with constant feedback from internal reliability monitoring; customer feedback on the results is a vital factor. The Fairchild power reliability concept can be presented as a constant feedback system which begins and ends with the customer. *(Figure 5-1).*

AREAS OF CONSIDERATION

Device Applications and Reliability

The reliability cycle begins with the customer. His device application, environment for its usage and end-product reliability requirements are major factors in establishing the quality/reliability levels for the power transistor. The customer is the final judge.

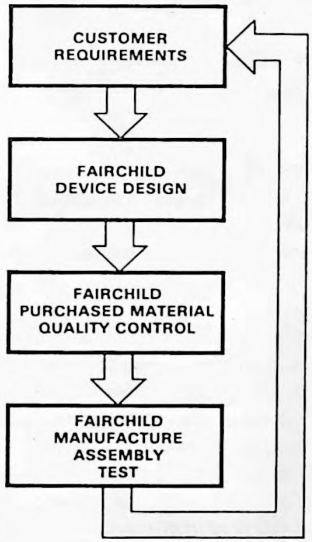
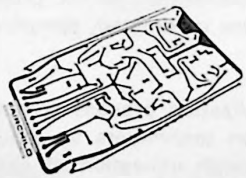


Fig. 5-1. Customer Feedback System



Customer Design Breadboard

Device Design

Inherent component reliability is a function of the product/process design. Most Fairchild power transistor designs are not totally new, but instead are modifications or extensions of existing designs with known performance and reliability characteristics. Three different aspects of the power device significantly affect its reliability.

The Silicon Chip

Impurity profiles determine safe operating area (SOA) trade-offs with other electrical parameters. Fairchild's design-technology capability utilizes multiple epitaxial layers to optimize (SOA) performance while still achieving the desired electrical parameter characteristics. Where severe current distribution problems exist, discrete emitter topology is used to eliminate current crowding and hot spots. The surface influences long term gain and voltage/leakage stability. The metalization determines mechanical integrity and current distribution.

Assembly of the Chip to the Package.

The processes and materials used must preserve the inherent reliability of the chip and be reliable in themselves to withstand mechanical and electrical stresses.

The Package

The package must effectively transfer heat from the chip to the outside world and protect the chip during handling and use.

Incoming Quality Control (IQC)

All purchased materials for Fairchild power transistors are controlled through central specification control, product engineering and reliability and quality assurance (R&QA) located in Mountain View. Materials are purchased and inspected per control documents using three IQC methods.

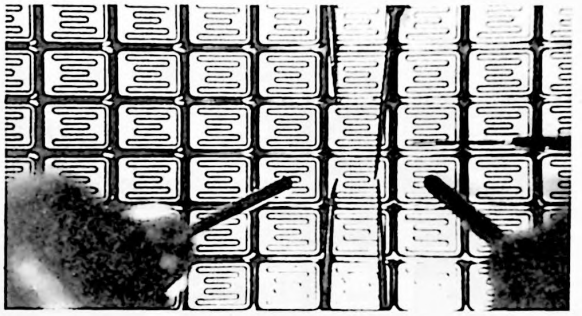
Direct inspection
Functional testing
Submission to outside laboratories for chemical and X-ray analysis.

In additon to centralized IQC, each manufacturing facility has a local, fully equipped IQC department. These facilities concentrate on cleanliness, plating quality and functionality. A computer file is made on each vendor's performance and quarterly reports are generated and analyzed.

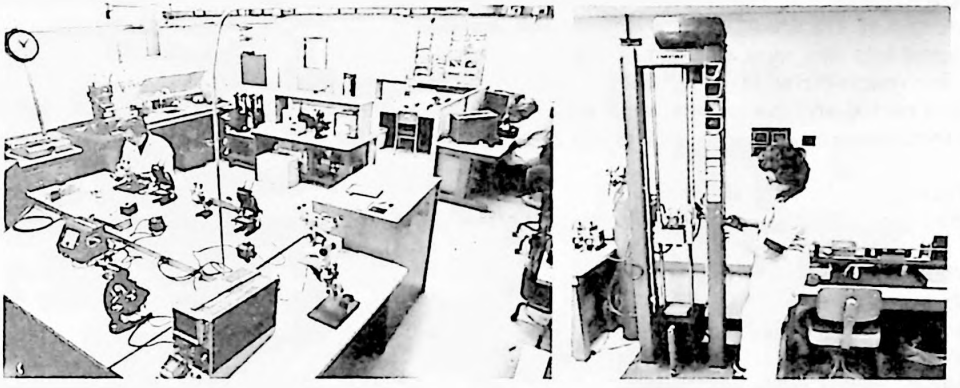
WAFER MANUFACTURE

All wafers used to fabricate Fairchild power transistors are made at Fairchild. This includes crystal pulling, slicing, polishing and equitaxial layer growth. Fairchild's power multiple-epitaxial designs rely on tight control of thickness and resistivity over a three-inch diameter wafer. As many as three epi-layers are used to achieve the designed impurity profile. Extreme cleanliness is a must in all operations. All critical operations have laminar-flow clean-air hoods directly over the work areas. Wafer fabrication is essentially a series of furnace masking cycles in which geometries are defined and impurities (doping) introduced to form emitter, base and contact regions. Daily controls are maintained on furnace temperatures to within ±1°C. Resistivities (V/I) of diffused layers are recorded on every run. Each masking cycle, which defines a new area of the geometry to be "worked on", has develop check to assure each wafer has received proper exposure and chemical development. When masking is completed, a final check establishes that the proper areas are clean and properly etched. Since operations in the masking area are automated, sampling of runs is very effective in controlling the process.

After masking and diffusion, the metalization process completes wafer manufacture. Fairchild uses filament and electron-beam evaporation techniques to deposit gold, chrome, silver, palladium and aluminum. Deposits are controlled through utilization of automated process sequencing, sloan frequency monitors for thickness control and premeasured metal charges which are depleted during the deposition cycle. Every run is gated through a first optical (1st opt.) inspection before it leaves fab. Cleanliness, mask alignment, metal adherence (front and back) and general workmanship are inspected.



Wafer Probing



IQC Area

Crystal Puller

Wafer Testing
Before the wafers are scribed and broken into dice for assembly onto headers or shipment to a customer as probed dice, they are electrically sorted. Each wafer is automatically probed with 5 to 7 tests to duplicate or correlate the dice to the final product test requirements. Typical probe tests are I_{CBO}, I_{CES}, h_{FE}, $V_{CEO(sus)}$ and BV_{EBO}. Rejected dice are ink marked and later scrapped. A final quality control gate is performed before the probed wafers can be forwarded to assembly.

Device Assembly
After the wafers are scribed and broken, a second optical (2nd opt.) QC inspection is performed. The dice are inspected for post wafer fabrication (handling) damage, as well as for defects which may cause assembly problems such as missing metal in a bonding pad.

Monitors are performed on both assembly equipment and operators. Machines are shut down if defect control limits are exceeded and suspect material is rejected and 100% screened. Key items inspected are die orientation, voids under die, proper bond formation, wirepull strength and cleanliness.

A third optical (3rd opt.) gate is performed prior to final device sealing. At this inspection point, each lot is inspected to a 1.5% AQL. If rejected, the lot is 100% screened by production and resubmitted to QC. Accepted lots are sent to the final seal operation, where the packages are monitored for weld strength and hermeticity (except plastic packages). TO-39 packaged devices are temperature aged, temperature cycled and impact shocked before submission to the test area. TO-3/66/220 packaged devices are temperature aged and I_{SB} (Forward Biased Safe Operating Area) tested prior to test.

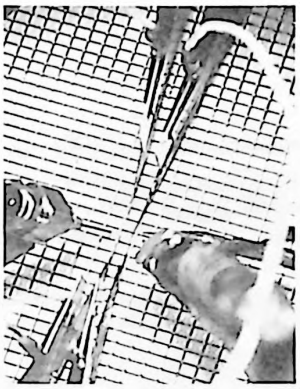
Device Testing.
Before shipment, all devices are 100% production tested to the following minimum inspection levels.

Catastrophics(O/S)	0.25% AQL
25°C dc	0.65% AQL
25°C ac	2.5 % AQL
Temperature dc	15/2 LTPD
Mechanical/Visual	1.0% AQL
Solderability	15/2 LTPD
SOA (TO-3/66/220)	1.0% AQL

Customers with special requirements are accommodated through an internal specification system. All internal test specifications formatted from customer documents are signed off by QA before they can be issued to the test area.

Device Application
The total reliability effort is completed full cycle with the customer. Operation in the customer application is the final consideration in device reliability. How each device is handled during system assembly by the customer, heat-sunk (mounted) and cooled during operation, and the amount of overload stresses (due to the system malfunction or misuse), greatly impacts the device reliability. Thus the customer's specification requirements, the manufacturer's device design, manufacture, test, the actual circuit into which the device is inserted and the equipment containing that circuit in the field all affect the device and reliability.

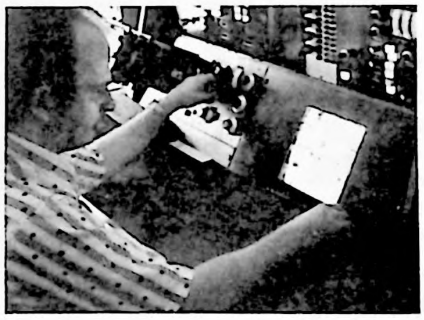
FAILURE ANALYSIS
Failure analysis results performed by customers and by Fairchild on returned devices provide one of the most important inputs for consideration in Fairchild's total power reliability concept.
Failures generated by line monitors, life tests and field applications are analyzed to provide corrective action in terms of product design, assembly and testing methods. A scanning electron microscope (SEM) and an Auger electron microscope for chemical analysis are available for inspection of materials. The basic failure modes include the following.



Die Probing

Device Testing

IQC Sign-off



Failure Analysis

Collector-Emitter Shorts
This is the most frequently reported failure mode of power transistors in the field. Collector-to-emitter shorts can result from a number of causes but the end result is usually chip overheating, and subsequent alloying of the aluminum metal through the active regions of the chip resulting in a shorted device.

Failure analysis involves:

Looking for foreign contamination which may have shorted the collector-base junction.

Looking for evidence of alloyed aluminum and its location. If failure occurred during forward-bias operation of the emitter-base junction, the failure will usually occur away from the emitter bond. If the emitter-base junction was reverse biased, the alloyed region is more typically adjacent to or under the emitter bond.

Removing the chip and looking for evidence of voids in the die-attach interface, which could have caused excessive chip temperature even though the header temperature remained within acceptable limits.

I_{SB}/E_{SB}/SOA
I_{SB} is forward-biased second breakdown or "current snapback"; E_{SB} is reverse-biased second breakdown. Each results in chip overheating and alloyed aluminum problems. SOA is safe-operating area and refers to both I_{SB}/E_{SB} in general. For most design considerations, once the SOA of a device is exceeded, catastrophic heating failure occurs immediately.

I_{CEO}/I_{CBO}
This leakage can be caused by any contamination on or near the collector-base junction. The contamination may be wafer related, assembly related or package related. The leakage affects subsequent circuit stages and causes $V_{CE} \times I_{CE}$ to generate excess heat in the power transistor.

I_{EBO} Drift
This is normally caused by ionic contamination of the wafer oxide. Because of the lower voltage involved, external contamination is usually not a factor. Main concern is loss of low current-gain performance.

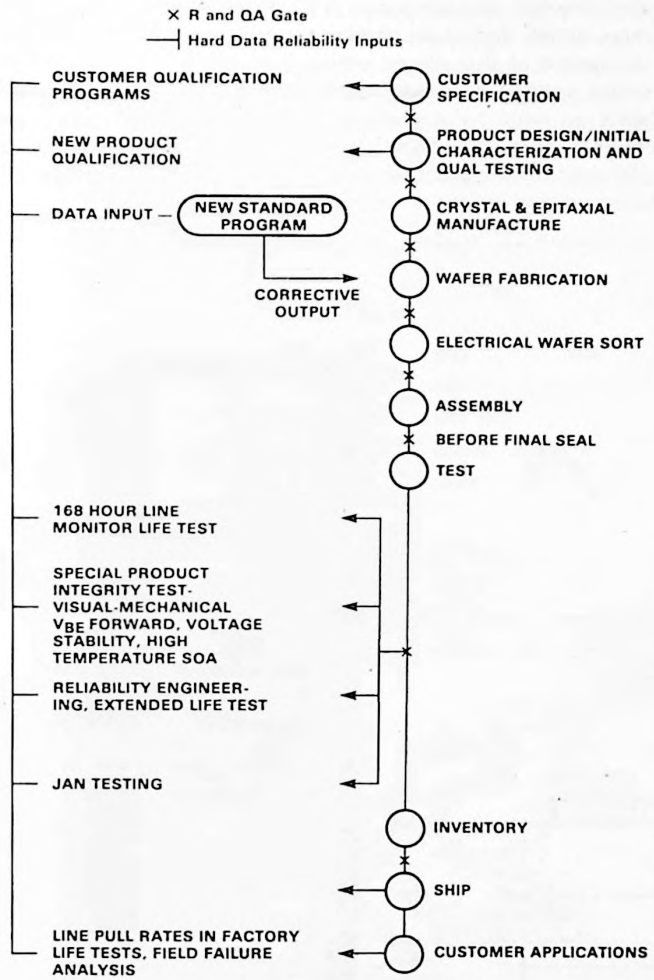
h_{FE} Degradation
This is essentially the same as I_{EBO} drift, but bulk degradation, usually near the surface, can occur from high I_{EBO} leakage or if the emitter-base junction is sustained in avalanche.

Opens
Opens can occur in the base or emitter circuits due to wires breaking or becoming detached and in the collector circuit if the die becomes separated from the header. The most common open failures are found in the emitter circuit since it usually has the highest current density.

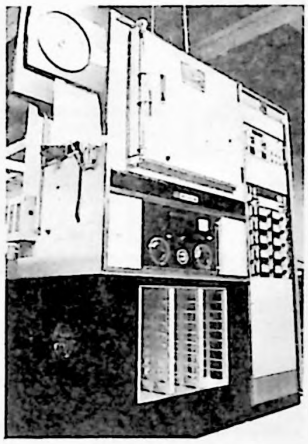
RELIABILITY MONITOR AND CONTROL

Through a central product filing review system, inputs from the areas discussed above are compared with life test data being continually generated. From this review system, necessary actions can be defined, documented and initiated. The reliability program using this review system is called the *new standard* program. The new standard program recognizes the total reliability concept and results in giving better definition of each product's reliability characteristics to enable the customer to use the product more effectively.

Life Cycle Flow Chart *(Figure 5-2)*
As part of the new standard program, Fairchild employs a product life-cycle monitor and test system, planned to define control and improve device reliability.



Line Monitor



HTRB System

Fig. 5-2. Product Reliability Life Cycle Flow Chart

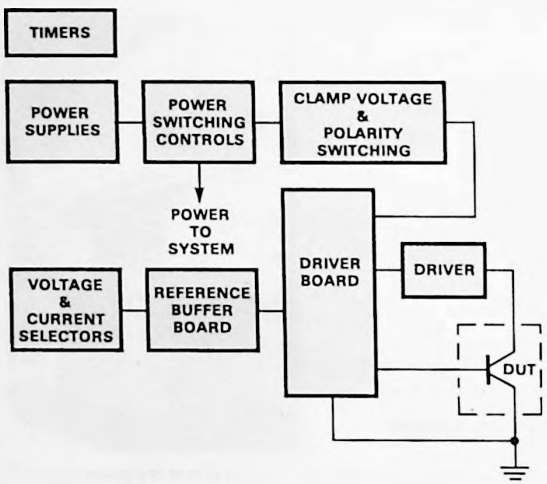
Line Monitors

Line monitors are used to monitor the production line on a weekly basis. These tests are accelerated and targeted to generate 10-20% failures. The following five test monitors are conducted on a routine basis.

High Temperature Reverse Bias
Intermittent Operating Life (Power Cycling)
High Temperature Storage
Temperature Cycling
Pressure Pot*

*applies to TO-220 devices only

Power Cycling *(Figure 5-3.)*
Fairchild has the capability of running power cycling tests under a wide variety of test conditions. The power cycle system utilizes unique circuitry for obtaining any ΔT_C. Base-to-emitter voltage in a transistor consists of the forward diode drop, which decreases at about 2 mV per °C, and the IR drop due to the emitter current and the bulk resistance of the silicon which increases at a rate of about 0.7% per °C. Consequently the base-to-emitter voltage is a reasonably accurate measure of junction temperature. As each device under test heats up with the application of emitter current and, as the base-to-emitter voltage lowers to a preselected reference voltage, the collector voltage for each device is lowered to maintain the V_{BE} and the junction temperature at a constant level. This means that any given case temperature can be maintained for any length of time within device limitations.



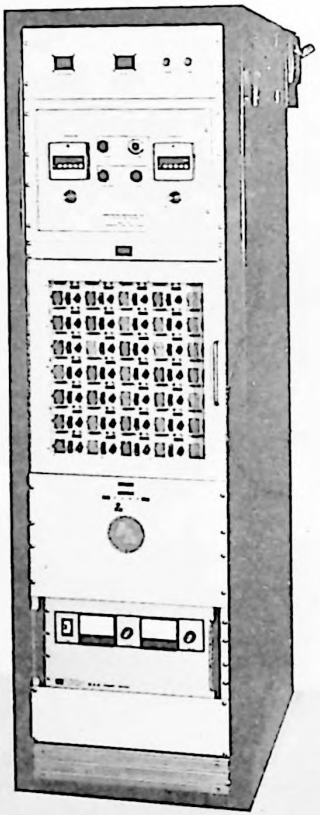


Fig. 5-3. Power Cycling System

Reliability Engineering Extended Life Testing

Figure 5-4 gives recent failure rates experienced on the various package types for the indicated stress condition. This data is used extensively to improve process control. For example, high-temperature reverse-bias results from testing a Planar* chip in a TO-5 package are used as indicators of similarly processed products. Fairchild has a selection of basic Planar chips in TO-5 packages. By using line monitor results on each individual product line, common factors can be eliminated, and unique problem areas quickly defined. *Figure 5-5* indicates Fairchild's current reliability program.

METAL CAN POWER

STRESS TEST	CONDITIONS	STRESS UNITS	FAILURE (RATES)*
Intermittent Operating Life (IOPL) TO-3	ΔT_C = 53°C P = 20 W, t_{on} = 35 s VCE = 7 V, t_{off} = 5 min.	34,600/wk. Device Cycles Line Monitor Lot Data	(.71)
(IOPL) TO-5	ΔT_C = 35°C P = 600 mW, t_{on} = 2 min. V_{CC} = 20 V, t_{off} = 2 min.	250,000/wk. Device Cycles Line Monitor Lot Data	(1.23)
High Temperature Reverse Bias (HTRB)	T_A = 150°C V_{CE} = 80% rated voltage	140,000 Device Hours Line Monitor Lot Data	(2.62)
High Temperature Storage (HTS)	T_A = 200°C	7.012×10^6 Dev. Hours Line Monitor Lot Data	(.29)
Temperature Cycle	T_A = -40°C to +125°C	17,500 Device Cycles	(4.0)
Operating Life (OPL) TO-5	P = 600 mW	140,000 Device Hours Line Monitor Lot Data	(1.93)

*Failures defined as inoperatives and degradation greater than specification limit +20%. Failure rates are best estimate, % per 1000 hours (cycles).

PLASTIC POWER

STRESS TEST	CONDITIONS	STRESS UNITS	FAILURE (RATES)*
Intermittent Operating Life (IOPL)	ΔT_C = 90°C P = 0.8 W, t_{on} = 45 s V_{CE} = 8 V, t_{off} = 90 s	2.1×10^5 cycles/week (100% Line Monitor Lot Data)	10% at 9,255 cycles
High Temperature Reverse Bias (HTRB)	T_C = 150°C V_{CE} = 80% rated voltage	4,320 Device Hours	0
Wet High Temperature Reverse Bias (WHTRB)	T_A = 85°C RH = 85%	17,336 Device Hours	0
High Temperature Storage (HTS)	T_A = 150°C	1×10^6 Device Hours	(.37)
Temperature Cycle	T_A = -40°C to +100°C	12,500 Device Cycles	Four Failures
Temperature Shock	T_A = 0 to +100°C	2,500 Device Cycles	0
Moisture Resistance	T_A = 40°C RH = 95%	3,000 Device Hours	0
Pressure Pot	T_A = 138°C P = 15 psi t = 4 hours	4,000 Device Hours	Two Failures

*Where applicable, actual results are stated where data is insufficient to project meaningful failure rates. Failures defined as inoperatives. Failure rates are best estimate, % per 1000 hours (cycles).

Fig. 5-4. Extended Life Test Data

*Planar is a patented Fairchild process.

TEST	TO-3	TO-66	TO-5	TO-220
High Temperature Storage T_A = 200°C (MIL-STD-750, Method 1031) Readout at 0, 168, 500, 1000 Hours	X	X	X	X
Intermittent Operating Life (MIL-STD-750, Method 1036) ΔT_C = 90°C Readouts at 0, 5K, 10K, 15K, 20K Cycles	X	X	X	
Intermittent Operating Life ΔT_C = 100°C Readouts at 1, 5K, 10K, 20K Cycles				X
High Temperature Reverse Bias T_A = 150°C, 80% BV_{CEO} Readouts at 0, 168, 500, 1000 Hours	X	X	X	X
Temperature Cycling -65°C to +200°C (MIL-STD-750, Method 1051, Cond. C) Readouts at 0, 25 Cycles Hermiticity (1×10^{-7})	X	X	X	
Steady State Operating Life T_J = 187.5°C ± 12.5°C (MIL-STD-750, Method 1026) Readouts at 0, 168, 500, 1000 Hours	X	X	X	
Constant Acceleration F = 20K g 1 Min. Ea. 6 Axis (MIL-STD-750, Method 2006)	X	X	X	
Impact Shock 1500 g x 5 Blows (MIL-STD-750, Method 2016)	X	X	X	
Vibration, Variable Frequency 10 g (MIL-STD-750, Method 2056)	X	X	X	
Wet HTRB T_A = 85°C, RH = 80% BV_{CEO} Readouts at 0, 168, 500, 1000 Hours				X
Temperature Cycling -40°C to +150°C Readouts at 0, 25 Cycles				X
Pressure Pot T_A = 123°C ± 2°C 15 PSI, 4 Hours				X
Shelf Life T_A = 25°C Readouts at 0, 1K, 2K, 10K Hours				X

Fig. 5-5. Reliability Program 1976

JAN POWER DEVICES

Fairchild power devices have the capability of meeting JAN performance criteria when subjected to the rigid requirements of JAN military specifications. The chart in *Figure 5-6* shows typical JAN acceptance testing.

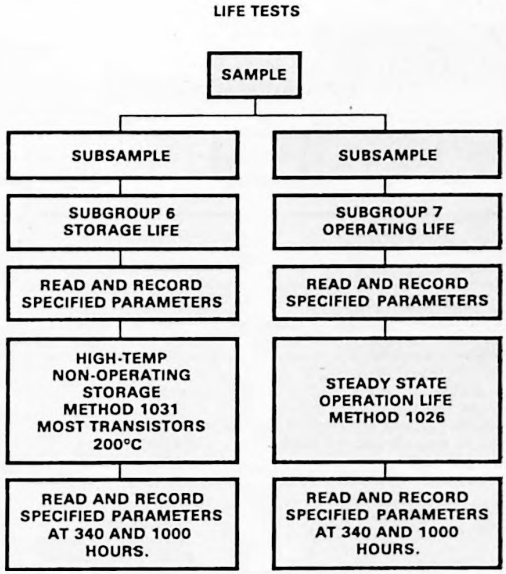
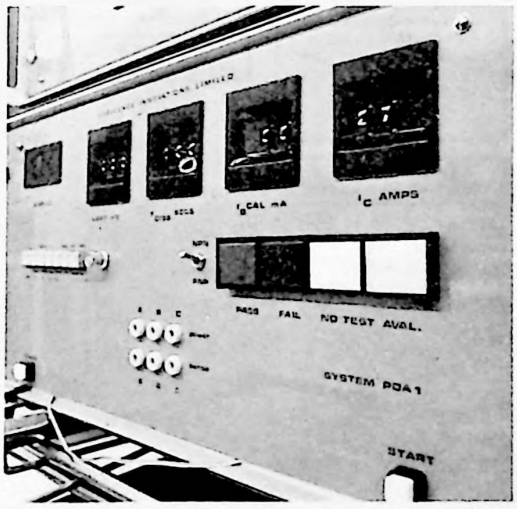


Fig. 5-6. Typical JAN Acceptance Testing



Voltage-Monitoring System for JAN Devices

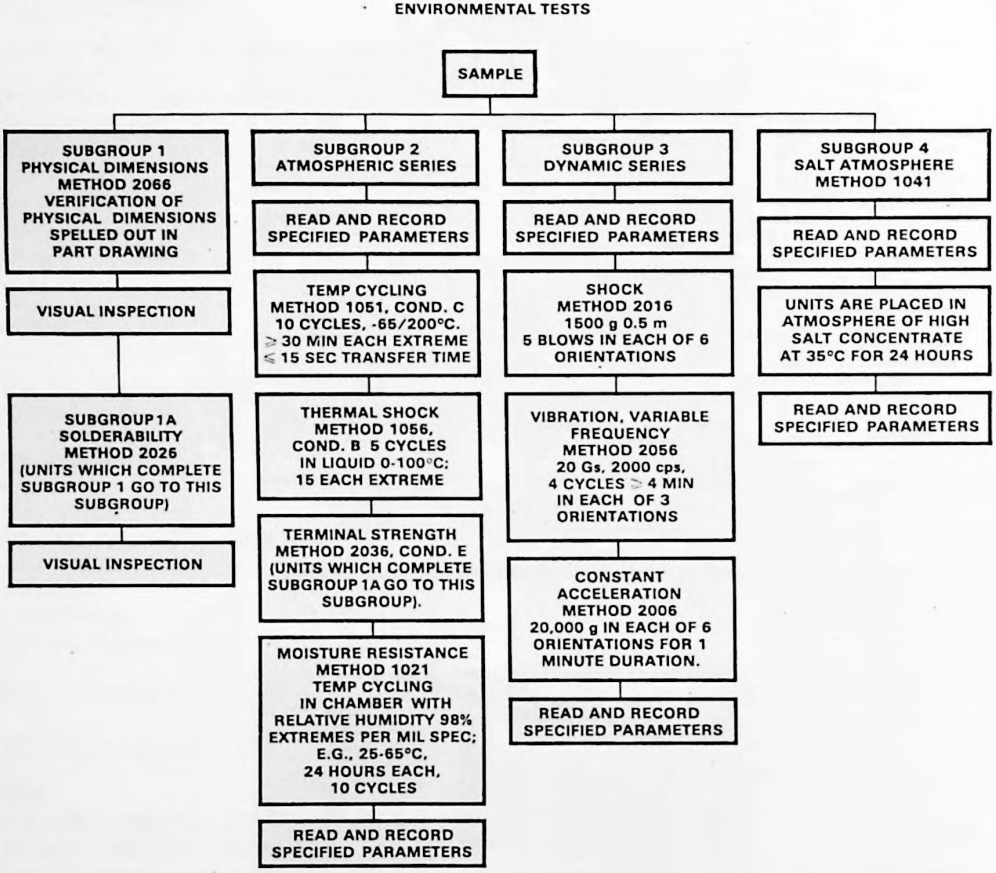
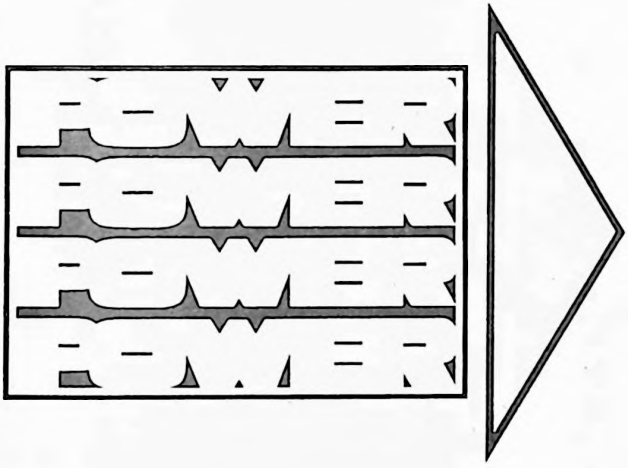


Fig. 5-6. Typical JAN Acceptance Testing (Cont'd)



DEVICE SELECTION GUIDES AND CROSS REFERENCE

POWER TRANSISTOR TECHNOLOGY 1

SAFE OPERATING AREA 2

POWER TRANSISTOR MANUFACTURING 3

POWER TRANSISTOR PACKAGING AND HEAT SINKING 4

POWER TRANSISTOR RELIABILITY 5

PRODUCT INFORMATION 6

DEFINITIONS OF SYMBOLS AND TERMS 7

FAIRCHILD FIELD SALES OFFICES, SALES REPRESENTATIVES, DISTRIBUTOR LOCATIONS 8

POWER TRANSISTOR

NPN SILICON

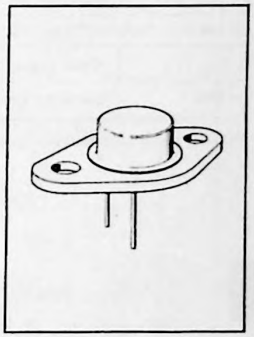
2N3054

DESIGNED FOR INTERMEDIATE POWER APPLICATIONS IN INDUSTRIAL AND COMMERCIAL EQUIPMENT

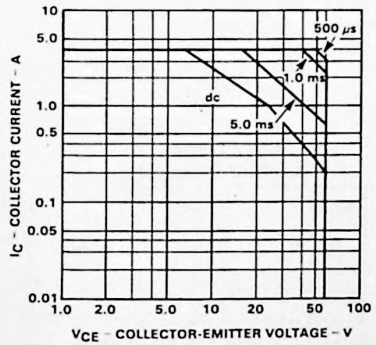
- 25 W DISSIPATION AT 25°C CASE
- 4.0 A MAXIMUM CONTINUOUS COLLECTOR CURRENT
- 55 V MINIMUM V_{CEO}

ABSOLUTE MAXIMUM RATINGS (Note 1)

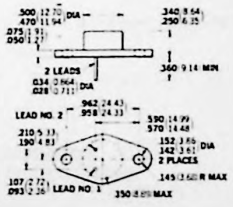
		2N3054
Maximum Voltages and Currents		
V_{CEO}	Collector to Emitter Voltage	55 V
V_{CBO}	Collector to Base Voltage	90 V
V_{EBO}	Emitter to Base Voltage	7.0 V
I_C	Continuous Collector Current	4.0 A
I_B	Continuous Base Current	2.0 A
Maximum Power Dissipation		
P_D	Total Dissipation @ 25°C Case Temperature	25 W
	Derate Linearly from 25°C	0.143 W/°C
Maximum Temperatures		
T_J, T_{stg}	Storage and Operation Junction Temperatures	−65°C to +200°C
Thermal Characteristics		
$R_{\theta JC}$	Thermal Resistance, Junction to Case	7.0°C/W



SAFE OPERATING AREA



JEDEC (TO-66) Outline



NOTES:
All dimensions in inches (bold) and millimeters (parentheses)
Pins are gold-plated kovar
Pins 1 and 2 electrically isolated from case
Case is third electrical connection
Nickel-plated steel base and cap
Package weight is 6.5 grams

6

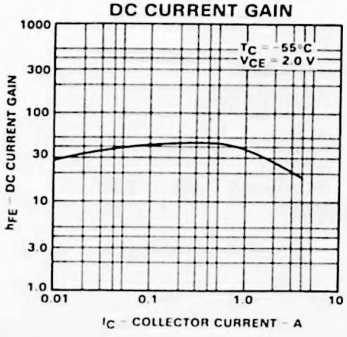
ELECTRICAL CHARACTERISTICS (25°C Case Temperature unless otherwise noted)

SYMBOL	CHARACTERISTIC	2N3054 MIN	2N3054 MAX	UNIT	TEST CONDITIONS
OFF CHARACTERISTICS					
$V_{CEO(sus)}$	Collector-Emitter Sustaining Voltage (Note 1)	55		V	I_C = 100 mA, I_B = 0
$V_{CER(sus)}$	Collector-Emitter Sustaining Voltage (Note 1)	60		V	I_C = 100 mA, R_{BE} = 100 Ω
I_{CEO}	Collector Cutoff Current		0.5	mA	V_{CE} = 30 V, I_B = 0
I_{CEX}	Collector Cutoff Current		1.0 6.0	mA mA	V_{CE} = 90 V, V_{BE} = −1.5 V V_{CE} = 90 V, V_{BE} = −1.5 V, T_C = 150°C
I_{EBO}	Emitter Cutoff Current		1.0	mA	V_{EB} = 7.0 V, I_C = 0
ON CHARACTERISTICS					
h_{FE}	DC Current Gain (Note 1)	25 5.0	150		I_C = 500 mA, V_{CE} = 4.0 V I_C = 3.0 A, V_{CE} = 4.0 V
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage (Note 1)		1.0 6.0	V V	I_C = 500 mA, I_B = 50 mA I_C = 3.0 A, I_B = 1.0 A
$V_{BE(on)}$	Base-Emitter "On" Voltage (Note 1)		1.7	V	I_C = 500 mA, V_{CE} = 4.0 V
DYNAMIC CHARACTERISTICS					
h_{fe}	Small Signal Current Gain	25	180		I_C = 100 mA, V_{CE} = 4.0 V, f = 1.0 kHz
fhfe	Common-Emitter Cutoff Frequency	30		kHz	I_C = 100 mA, V_{CE} = 4.0 V

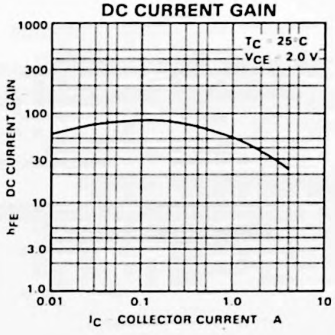
NOTE: 1. Pulse condition; Length = 300μs, Duty Cycle = 2%.

TYPICAL ELECTRICAL CHARACTERISTICS

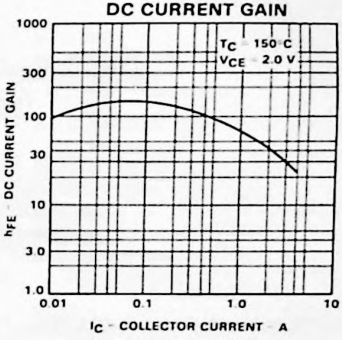
DC CURRENT GAIN



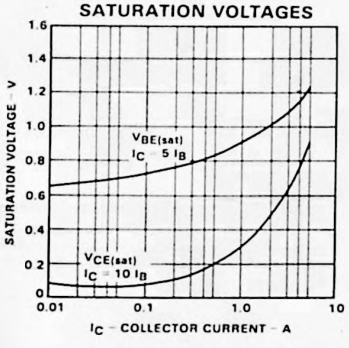
DC CURRENT GAIN



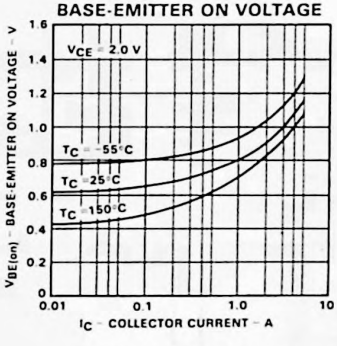
DC CURRENT GAIN



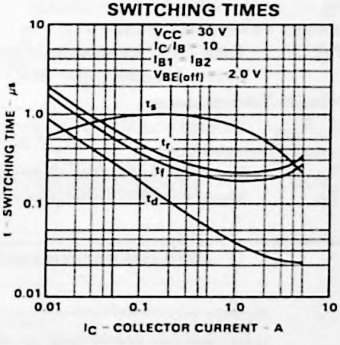
SATURATION VOLTAGES



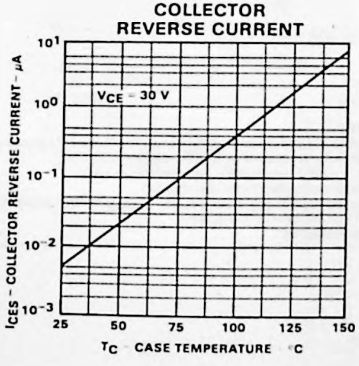
BASE-EMITTER ON VOLTAGE



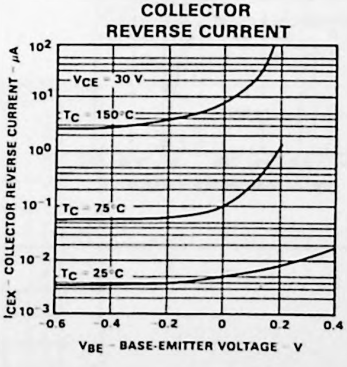
SWITCHING TIMES



COLLECTOR REVERSE CURRENT



COLLECTOR REVERSE CURRENT



6

POWER TRANSISTOR

NPN SILICON

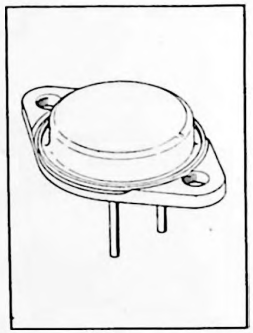
2N3055

DESIGNED FOR GENERAL PURPOSE AMPLIFIER AND SWITCHING APPLICATIONS

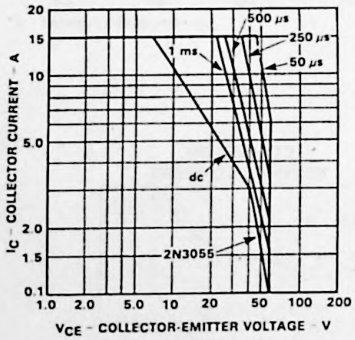
- 115 W DISSIPATION AT 25°C CASE
- 15 A MAXIMUM CONTINUOUS COLLECTOR CURRENT
- DC CURRENT GAIN SPECIFIED TO 10 A

ABSOLUTE MAXIMUM RATINGS (Note 1)

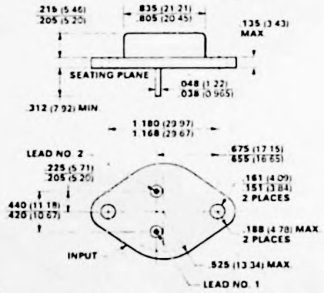
Maximum Voltages and Currents		
V_{CEO}	Collector to Emitter Voltage	60 V
V_{CBO}	Collector to Base Voltage	100 V
V_{EBO}	Emitter to Base Voltage	7.0 V
I_C	Continuous Collector Current	15 A
I_B	Continuous Base Current	7.0 A
Maximum Power Dissipation		
P_D	Total Dissipation @ 25°C Case Temperature	115 W
	Derate Linearly from 25°C	0.65 W/°C
Maximum Temperatures		
T_J, T_{stg}	Storage and Operation Junction Temperatures	−65°C to +200°C
Thermal Characteristics		
$R_{\theta JC}$	Thermal Resistance, Junction to Case	1.5°C/W
T_P	Maximum Pin Temperature (Soldering, 10 s)	235°C



SAFE OPERATING AREA



JEDEC (TO-3) Outline



NOTES:
All dimensions in inches (bold) and millimeters (parentheses)
Pins are gold-plated or solder-dipped alloy 52
Pins 1 and 2 electrically isolated from case
Case is third electrical connection
Aluminum package with copper slug, pins are soldered in
Package weight is 7.4 grams
Aluminum cap

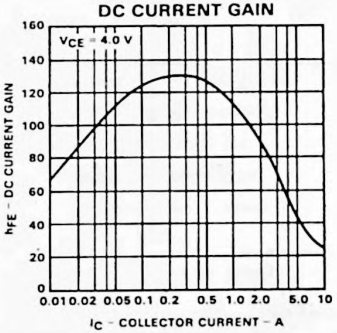
ELECTRICAL CHARACTERISTICS (25°C Case Temperature unless otherwise noted)

SYMBOL	CHARACTERISTIC	2N3055 MIN	2N3055 MAX	UNIT	TEST CONDITIONS
OFF CHARACTERISTICS					
$V_{CEO(sus)}$	Collector-Emitter Sustaining Voltage (Note 1)	60		V	I_C = 200 mA, I_B = 0
$V_{CER(sus)}$	Collector-Emitter Sustaining Voltage (Note 1)	70		V	I_C = 200 mA, R_{BE} = 100 Ω
I_{CEO}	Collector Cutoff Current		0.7	mA	V_{CE} = 30 V, I_B = 0
I_{CEX}	Collector Cutoff Current		5.0 30	mA mA	V_{CE} = 100 V, V_{BE} = −1.5 V V_{CE} = 100 V, V_{BE} = −1.5 V, T_C = 150°C
I_{EBO}	Emitter Cutoff Current		5.0	mA	V_{EB} = 7.0 V, I_C = 0
ON CHARACTERISTICS					
h_{FE}	DC Current Gain (Note 1)	5.0 20	 70		I_C = 10 A, V_{CE} = 4.0 V I_C = 4.0 A, V_{CE} = 4.0 V
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage (Note 1)	1.1 8.0		V V	I_C = 4.0 A, I_B = 400 mA I_C = 10 A, I_B = 3.3 A
$V_{BE(on)}$	Base-Emitter "On" Voltage (Note 1)		1.8	V	I_C = 4.0 A, V_{CE} = 4.0 V
SECOND BREAKDOWN					
$I_{S/b}$	Second Breakdown Collector Current with base forward biased	2.5		A	t = 1.0s (non repetitive), V_{CE} = 40 V
DYNAMIC CHARACTERISTICS					
h_{fe}	Small Signal Current Gain	15	120		I_C = 10 A, V_{CE} = 4.0 V, f = 1.0 kHz
f_{hfe}	Small Signal Cutoff Frequency	10		kHz	I_C = 1.0 A, V_{CE} = 4.0 V

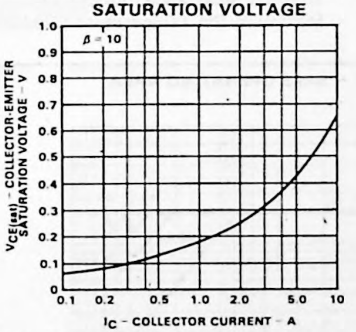
NOTE: 1. Pulse conditions: Length = 300 μs, Duty Cycle = 2%.

TYPICAL ELECTRICAL CHARACTERISTICS

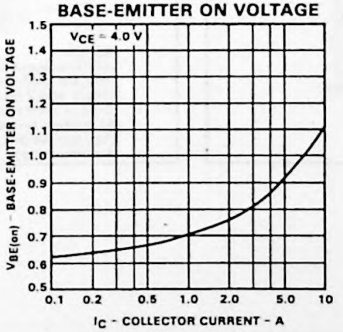
DC CURRENT GAIN



COLLECTOR-EMITTER SATURATION VOLTAGE



BASE-EMITTER ON VOLTAGE



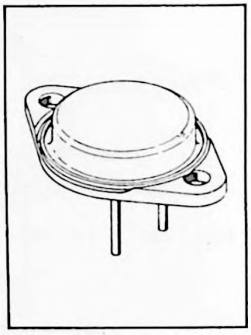
POWER TRANSISTOR

NPN SILICON

2N3055SD

DESIGNED FOR SERIES AND SHUNT REGULATORS POWER-SWITCHING CIRCUITS AND SOLENOID DRIVER APPLICATIONS IDEAL FOR A BROAD RANGE OF INDUSTRIAL AND COMMERCIAL USES

- 115 W DISSIPATION AT 25°C CASE
- 15 A MAXIMUM CONTINUOUS COLLECTOR CURRENT
- SOA (60 V, 1.95 A) GUARANTEED
- EQUIVALENT SINGLE DIFFUSED 2N3055



ABSOLUTE MAXIMUM RATINGS

Maximum Voltages and Currents

V_{CE}	Collector to Emitter Voltage	60 V
V_{CB}	Collector to Base Voltage	100 V
V_{EB}	Emitter to Base Voltage	7 V
I_C	Continuous Collector Current	15 A
I_B	Continuous Base Current	7 A

Maximum Power Dissipation

P_D	Total Dissipation @ 25°C Case Temperature	115 W
	Derate Linearly from 25°C	.657 W/°C

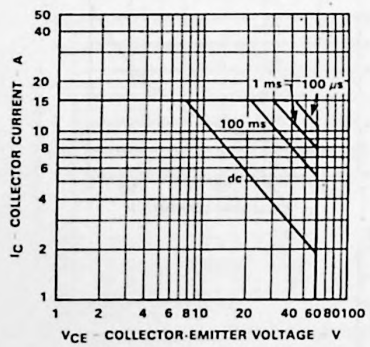
Maximum Temperatures

T_J, T_{stg}	Storage and Operating Junction Temperatures	−65°C to +200°C

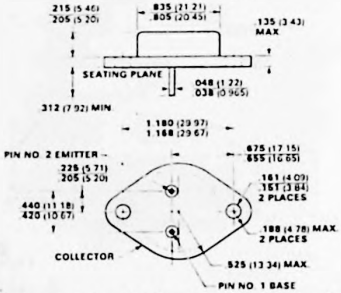
Thermal Characteristics

$R_{\theta JC}$	Thermal Resistance, Junction to Case	1.55°C/W
T_P	Maximum Pin Temperature (Soldering, 5 s)	235°C

SAFE OPERATING AREA



JEDEC (TO-3) Outline



NOTES:
All dimensions in inches (bold) and millimeters (parentheses)
Pins are gold-plated or solder-dipped alloy 52
Pins 1 and 2 electrically isolated from case
Case is third electrical connection
Aluminum package with copper slug, pins are soldered in
Package weight is 7.4 grams
Aluminum cap

ELECTRICAL CHARACTERISTICS (25°C Case Temperature unless otherwise noted)

SYMBOL	CHARACTERISTIC	MIN	MAX	UNITS	TEST CONDITIONS
OFF CHARACTERISTICS					
$V_{CEO(sus)}$	Collector-Emitter Sustaining Voltage (Note 1)	60		V	I_C = 200 mA, I_B = 0
$V_{CER(sus)}$	Collector-Emitter Sustaining Voltage (Note 1)	70		V	I_C = 200 mA, R_{BE} = 100 Ω
$V_{CEX(sus)}$	Collector-Emitter Sustaining Voltage (Note 1)	90		V	I_C = 100 mA, $V_{BE(off)}$ = −1.5 V
I_{CEO}	Collector Cutoff Current		0.7	mA	V_{CE} = 30 V, I_B = 0
I_{CEX}	Collector Cutoff Current		5.0 30	mA	V_{CE} = 100 V, V_{BE} = −1.5 V V_{CE} = 100 V, V_{BE} = −1.5 V, T_C = 150°C
I_{EBO}	Emitter Cutoff Current		5.0	mA	V_{EB} = 7.0 V, I_C = 0
ON CHARACTERISTICS					
h_{FE}	DC Current Gain (Note 1)	20 5.0	70		I_C = 4.0 A, V_{CE} = 4.0 V I_C = 10 A, V_{CE} = 4.0 V
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage (Note 1)		1.1 8.0	V	I_C = 4.0 A, I_B = 0.4 A I_C = 10 A, I_B = 3.3 A
$V_{BE(on)}$	Base-Emitter "On" Voltage (Note 1)		1.8	V	I_C = 4.0 A, V_{CE} = 4.0 V
SECOND BREAKDOWN					
$I_{s/b}$	Second Breakdown Collector Current with Base Forward Biased	1.95		A	t = 1.0 s (non-repetitive) V_{CE} = 60 V
DYNAMIC CHARACTERISTICS					
f_T	Current-Gain-Bandwidth Product	800		kHz	I_C = 1.0 A, V_{CE} = 4.0 V, f = 0.4 MHz
f_{hfe}	Common Emitter Small Signal Cutoff Frequency	10		kHz	I_C = 1.0 A, V_{CE} = 4.0 V
h_{fe}	Small Signal Current Gain	15	120		I_C = 1.0 A, V_{CE} = 4.0 V, f = 1 kHz

NOTE: 1. Pulse conditions: Length = 300 μs, Duty Cycle = 2%.

POWER TRANSISTOR

NPN SILICON

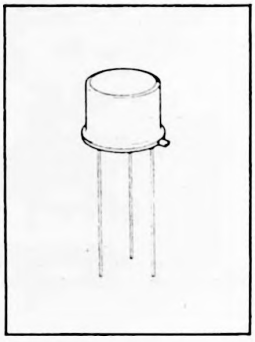
2N3439
2N3440

HIGH VOLTAGE POWER TRANSISTORS DESIGNED FOR USE IN CONSUMER AND INDUSTRIAL LINE-OPERATED APPLICATIONS

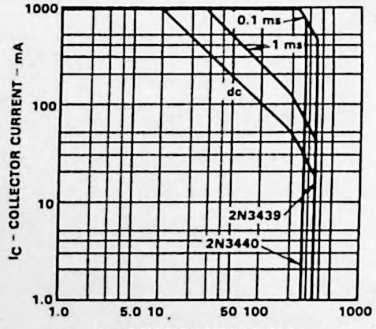
- 10 W DISSIPATION AT 25°C CASE
- 1.0 A MAXIMUM CONTINUOUS COLLECTOR CURRENT
- 350 V MINIMUM V_{CEO} (2N3439)

ABSOLUTE MAXIMUM RATINGS (Note 1)

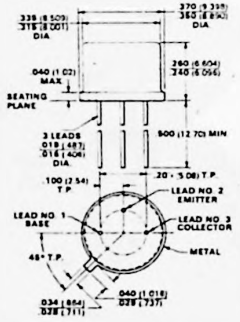
		2N3439	2N3440
Maximum Voltages and Currents			
V_{CEO}	Collector to Emitter Voltage	350 V	250 V
V_{CBO}	Collector to Base Voltage	450 V	300 V
V_{EBO}	Emitter to Base Voltage	7.0 V	7.0 V
I_C	Continuous Collector Current	1.0 A	1.0 A
I_B	Continuous Base Current	0.5 A	0.5 A
Maximum Power Dissipation			
P_D	Total Dissipation @ 25°C Case Temperature		10 W
	Derate Linearly from 25°C		0.57 W/°C
Maximum Temperatures			
T_J, T_{stg}	Storage and Operation Junction Temperatures		−65°C to +200°C
Thermal Characteristics			
$R_{\theta JC}$	Thermal Resistance, Junction to Case		17.5°C/W



SAFE OPERATING AREA



JEDEC (TO-39) outline



NOTES:
All dimensions in inches (bold) and millimeters (parentheses)
Leads are gold-plated kovar
Lead No. 3 connected to case
Package weight is 0.76 gram

ELECTRICAL CHARACTERISTICS (25°C Case Temperature unless otherwise noted)

SYMBOL	CHARACTERISTIC	2N3439		2N3440		UNIT	TEST CONDITIONS
		MIN	MAX	MIN	MAX		
OFF CHARACTERISTICS							
$V_{CEO(sus)}$	Collector-Emitter Sustaining Voltage (Note 1)	350		250		V	I_C = 50 mA, I_B = 0
I_{CEO}	Collector Cutoff Current		20		50	μA μA	V_{CE} = 300 V, I_B = 0 V_{CE} = 200 V, I_B = 0
I_{CEX}	Collector Cutoff Current		500		500	μA μA	V_{CE} = 450 V, V_{BE} = −1.5 V V_{CE} = 300 V, V_{BE} = −1.5 V
I_{CBO}	Collector Cutoff Current		20		20	μA μA	V_{CB} = 360 V, I_E = 0 V_{CB} = 250 V, I_E = 0
I_{EBO}	Emitter Cutoff Current		20		20	μA	V_{EB} = 6.0 V, I_C = 0
ON CHARACTERISTICS							
h_{FE}	DC Current Gain (Note 1)	30 40	160	40	160		I_C = 2.0 mA, V_{CE} = 10 V I_C = 20 mA, V_{CE} = 10 V
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage (Note 1)		0.5		0.5	V	I_C = 50 mA, I_B = 4.0 mA
$V_{BE(sat)}$	Base-Emitter Saturation Voltage (Note 1)		1.3		1.3	V	I_C = 50 mA, I_B = 4.0 mA
DYNAMIC CHARACTERISTICS							
f_T	Current-Gain-Bandwidth Product	15		15		MHz	I_C = 10 mA, V_{CE} = 10 V, f = 5.0 MHz
C_{ob}	Output Capacitance		10		10	pF	V_{CB} = 10 V, I_E = 0, f = 1.0 MHz
C_{ib}	Input Capacitance		75		75	pF	V_{EB} = 5.0 V, I_C = 0, f = 1.0 MHz
h_{fe}	Small Signal Current Gain	25		25			I_C = 5.0 mA, V_{CE} = 10 V, f = 1.0 kHz

NOTE: 1. Pulse conditions: Length = 300 μs, Duty Cycle = 2%.

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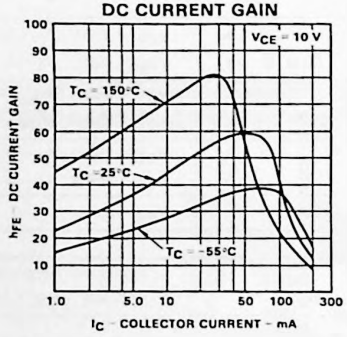
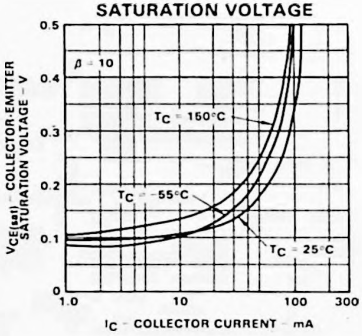
TYPICAL ELECTRICAL CHARACTERISTICS

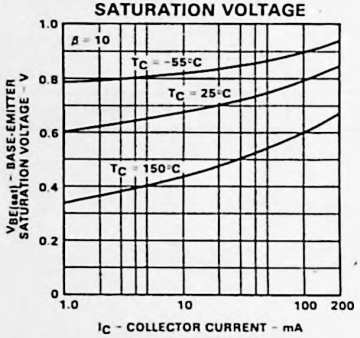
DC CURRENT GAIN



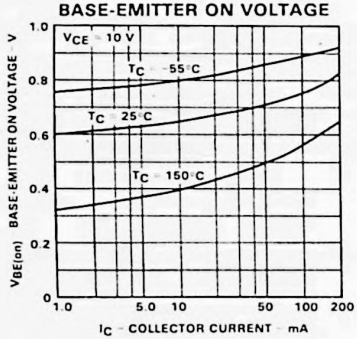
COLLECTOR-EMITTER SATURATION VOLTAGE



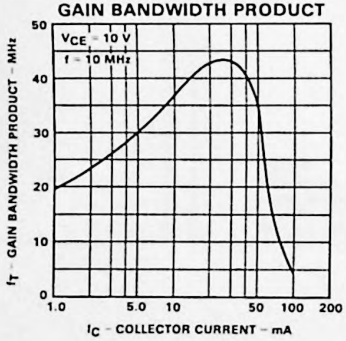
BASE-EMITTER SATURATION VOLTAGE



BASE-EMITTER ON VOLTAGE



GAIN BANDWIDTH PRODUCT



POWER TRANSISTOR

NPN SILICON

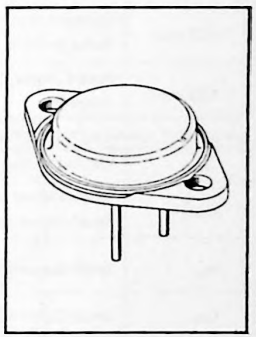
2N3713
2N3714
2N3715
2N3716

DESIGNED FOR MEDIUM-SPEED SWITCHING AND AMPLIFIER APPLICATIONS

- 150 W DISSIPATION AT 25°C CASE
- 10 A MAXIMUM CONTINUOUS COLLECTOR CURRENT
- COMPLEMENTS 2N3789 THRU 2N3792

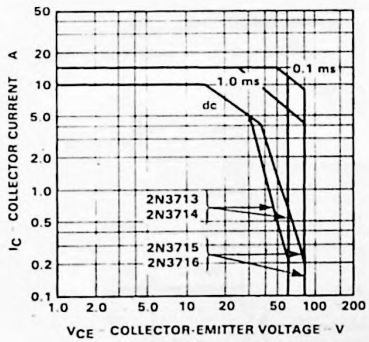
ABSOLUTE MAXIMUM RATINGS (Note 1)

		2N3713	2N3714	2N3715	2N3716
Maximum Voltages and Currents					
V_{CEO}	Collector to Emitter Voltage	60 V	80 V	60 V	80 V
V_{CBO}	Collector to Base Voltage	80 V	100 V	80 V	100 V
V_{EBO}	Emitter to Base Voltage	7.0 V	7.0 V	7.0 V	7.0 V
I_C	Continuous Collector Current	10 A	10 A	10 A	10 A
I_B	Continuous Base Current	4.0 A	4.0 A	4.0 A	4.0 A
Maximum Power Dissipation					
P_D	Total Dissipation @ 25°C Case Temperature				150 W
	Derate Linearly from 25°C				0.86 W/°C
Maximum Temperatures					
T_J, T_{stg}	Storage and Operation Junction Temperatures				−65°C to 200°C
Thermal Characteristics					
$R_{\theta JC}$	Thermal Resistance, Junction to Case				1.17°C/W

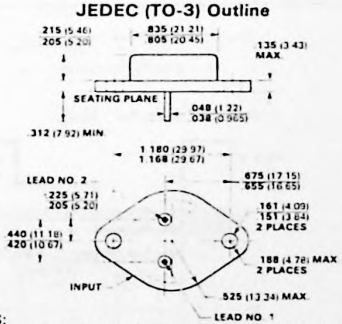


6

SAFE OPERATING AREA



JEDEC (TO-3) Outline



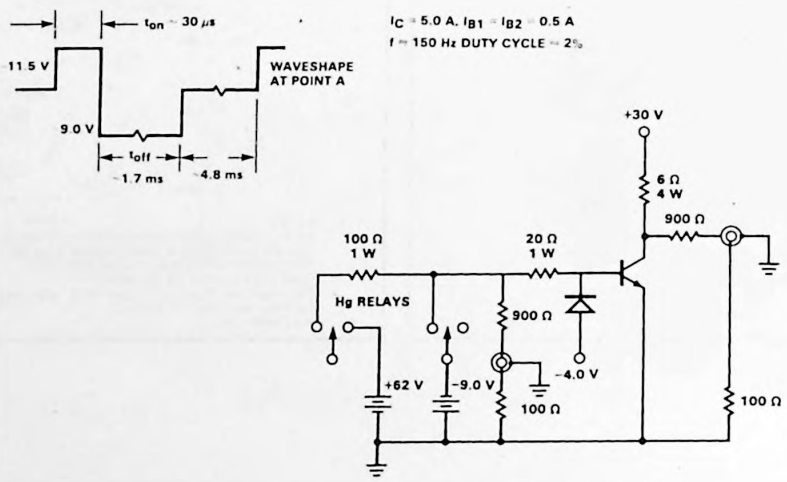
NOTES:
All dimensions in inches (bold) and millimeters (parentheses)
Pins are gold-plated or solder-dipped alloy 52
Pins 1 and 2 electrically isolated from case
Case is third electrical connection
Aluminum package with copper slug, pins are soldered in
Package weight is 7.4 grams
Aluminum cap

ELECTRICAL CHARACTERISTICS (25°C Case Temperature unless otherwise noted)

SYMBOL	CHARACTERISTIC	2N3713		2N3714		2N3715		2N3716		UNIT	TEST CONDITIONS
		MIN	MAX	MIN	MAX	MIN	MAX	MIN	MAX		
OFF CHARACTERISTICS											
$V_{CEO(sus)}$	Collector-Emitter Sustaining Voltage (Note 1)	60		80		60		80		V	I_C = 200 mA, I_B = 0
I_{CEO}	Collector Cutoff Current		0.7				0.7			mA	V_{CE} = 30 V, I_B = 0
					0.7				0.7	mA	V_{CE} = 40 V, I_B = 0
I_{CEX}	Collector Cutoff Current		1.0				1.0			mA	V_{CE} = 80 V, V_{BE} = −1.5 V
					1.0				1.0	mA	V_{CE} = 100 V, V_{BE} = −1.5 V
			10				10			mA	V_{CE} = 60 V, V_{BE} = −1.5 V, T_C = 150°C
					10				10	mA	V_{CE} = 80 V, V_{BE} = −1.5 V, T_C = 150°C
I_{EBO}	Emitter Cutoff Current		1.0		1.0		1.0		1.0	mA	V_{EB} = 7.0 V, I_C = 0
ON CHARACTERISTICS											
h_{FE}	DC Current Gain (Note 1)	5.0		5.0		5.0		5.0			I_C = 10 A, V_{CE} = 4.0 V
		25	75	25	75	50	150	50	150		I_C = 1.0 A, V_{CE} = 2.0 V
		15		15		30		30			I_C = 3.0 A, V_{CE} = 2.0 V
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage (Note 1)		1.0		1.0		0.8		0.8	V	I_C = 5.0 A, I_B = 500 mA
			4.0		4.0		4.0		4.0	V	I_C = 10 A, I_B = 2.0 A
$V_{BE(on)}$	Base-Emitter "On" Voltage (Note 1)		2.0		2.0		1.8		1.8	V	I_C = 5.0 A, V_{CE} = 2.0 V
			4.0		4.0		4.0		4.0	V	I_C = 10 A, V_{CE} = 4.0 V
DYNAMIC CHARACTERISTICS											
C_{ob}	Output Capacitance		250		250		250		250	pF	V_{CB} = 10 V, I_E = 0, f = 0.1 MHz
$\|h_{fe}\|$	Magnitude of Common Emitter Small Signal Current Gain	4.0		4.0		4.0		4.0			I_C = 500 mA, V_{CE} = 10 V, f = 1.0 MHz
h_{fe}	Small Signal Current Gain	25	250	25	250	25	250	25	250		I_C = 500 mA, V_{CE} = 10 V, f = 1.0 kHz
f_{hfe}	Small Signal Cutoff Frequency	30		30		30		30		kHz	I_C = 500 mA, V_{CE} = 10 V

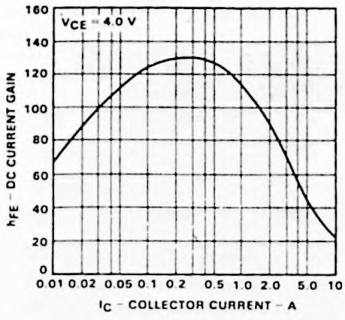
NOTE: 1. Pulse conditions: Length = 300 μs, Duty Cycle = 2%.

TEST CIRCUIT

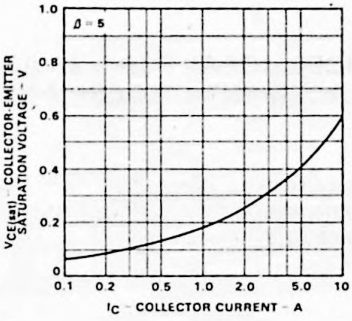


TYPICAL ELECTRICAL CHARACTERISTICS

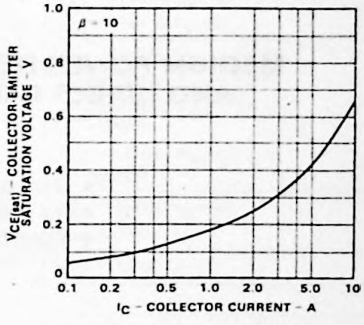
DC CURRENT GAIN



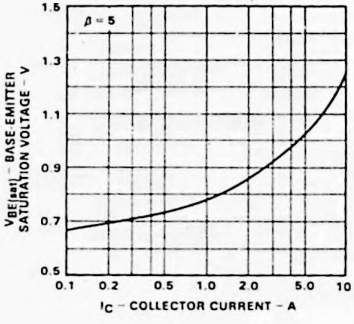
COLLECTOR-EMITTER SATURATION VOLTAGE



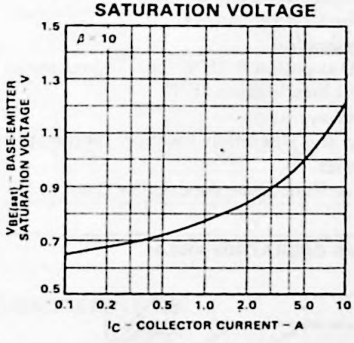
COLLECTOR-EMITTER SATURATION VOLTAGE



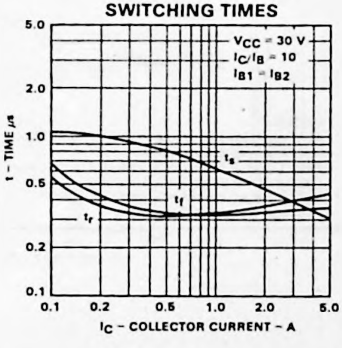
BASE-EMITTER SATURATION VOLTAGE



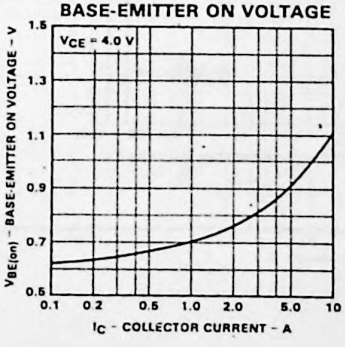
BASE-EMITTER SATURATION VOLTAGE



SWITCHING TIMES



BASE-EMITTER ON VOLTAGE



POWER TRANSISTOR

PNP SILICON

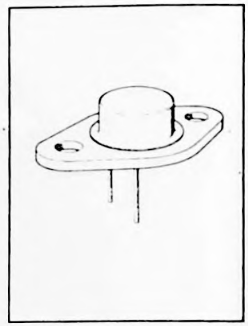
2N3740
2N3741

MEDIUM POWER DEVICES, IDEAL FOR USE AS DRIVERS, SWITCHES AND DIRECT REPLACEMENT OF GERMANIUM TRANSISTORS

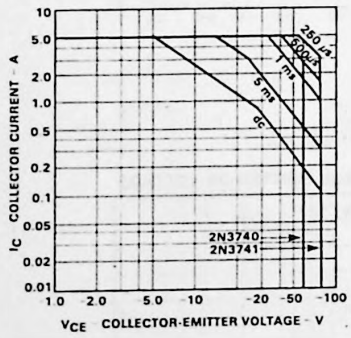
- 25 W DISSIPATION AT 25°C CASE
- 1.0 A MAXIMUM CONTINUOUS COLLECTOR CURRENT
- COMPLEMENTS 2N3766, 2N3767

ABSOLUTE MAXIMUM RATINGS (Note 1)

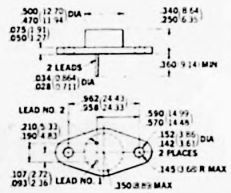
		2N3740	2N3741
Maximum Voltages and Currents			
V_{CEO}	Collector to Emitter Voltage	−60 V	−80 V
V_{CBO}	Collector to Base Voltage	−60 V	−80 V
V_{EBO}	Emitter to Base Voltage	−7.0 V	−7.0 V
I_C	Continuous Collector Current	1.0 A	1.0 A
I_B	Continuous Base Current	1.0 A	1.0 A
Maximum Power Dissipation			
P_D	Total Dissipation @ 25°C Case Temperature		25 W
	Derate Linearly from 25°C		0.14 W/°C
Maximum Temperatures			
T_J, T_{stg}	Storage and Operation Junction Temperatures		−65°C to +200°C
Thermal Characteristics			
$R_{\theta JC}$	Thermal Resistance, Junction to Case		7.0°C/W



SAFE OPERATING AREA



JEDEC (TO-66) Outline



NOTES:
All dimensions in inches (bold) and millimeters (parentheses)
Pins are gold-plated kovar
Pins 1 and 2 electrically isolated from case
Case is third electrical connection
Nickel-plated steel base and cap
Package weight is 6.5 grams

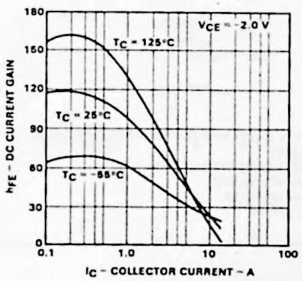
ELECTRICAL CHARACTERISTICS (25°C Case Temperature unless otherwise noted)

SYMBOL	CHARACTERISTIC	2N3740		2N3741		UNIT	TEST CONDITIONS
		MIN	MAX	MIN	MAX		
OFF CHARACTERISTICS							
$V_{CEO(sus)}$	Collector-Emitter Sustaining Voltage (Note 1)	−60		−80		V	I_C = 100 mA, I_B = 0
I_{CEO}	Collector Cutoff Current		1.0			mA	V_{CE} = −40 V, I_B = 0
					1.0	mA	V_{CE} = −60 V, I_B = 0
I_{CEX}	Collector Cutoff Current		0.1			mA	V_{CE} = −60 V, V_{BE} = 1.5 V
					0.1	mA	V_{CE} = −80 V, V_{BE} = 1.5 V
			1.0			mA	V_{CE} = −40 V, V_{BE} = 1.5 V, T_C = 150°C
					1.0	mA	V_{CE} = −60 V, V_{BE} = 1.5 V, T_C = 150°C
I_{CBO}	Collector Cutoff Current		0.1			mA	V_{CB} = −60 V, I_E = 0
					0.1	mA	V_{CB} = −80 V, I_E = 0
I_{EBO}	Emitter Cutoff Current		0.5		0.5	mA	V_{EB} = 7.0 V, I_C = 0
ON CHARACTERISTICS							
h_{FE}	DC Current Gain (Note 1)	40		40			I_C = 100 mA, V_{CE} = −1.0 V
		30	100	30	100		I_C = 250 mA, V_{CE} = −1.0 V
		20		20			I_C = 500 mA, V_{CE} = −1.0 V
		10		10			I_C = 1.0 A, V_{CE} = −1.0 V
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage (Note 1)		−0.6		−0.6	V	I_C = 1.0 A, I_B = 125 mA
$V_{BE(on)}$	Base-Emitter "On" Voltage (Note 1)		−1.0		−1.0	V	I_C = 250 mA, V_{CE} = −1.0 V
DYNAMIC CHARACTERISTICS							
f_T	Current-Gain-Bandwidth Product	4.0		4.0		MHz	I_C = 100 mA, V_{CE} = −10 V, f = 1.0 MHz
C_{ob}	Output Capacitance		100		100	pF	V_{CB} = −10 V, I_E = 0, f = 0.1 MHz
h_{fe}	Small Signal Current Gain	25		25			I_C = 50 mA, V_{CE} = −10 V, f = 1.0 kHz

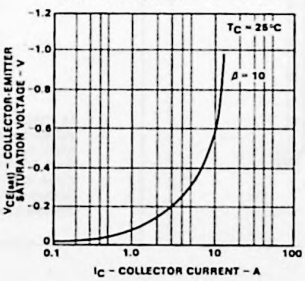
NOTE: 1. Pulse conditions: Length = 300 μs, Duty Cycle = 2%.

TYPICAL ELECTRICAL CHARACTERISTICS

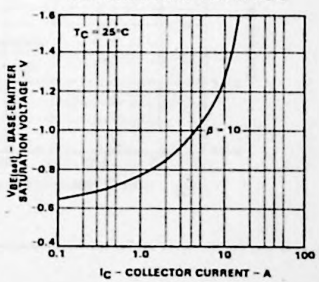
DC CURRENT GAIN



COLLECTOR-EMITTER SATURATION VOLTAGE



BASE-EMITTER SATURATION VOLTAGE



POWER TRANSISTOR

NPN SILICON

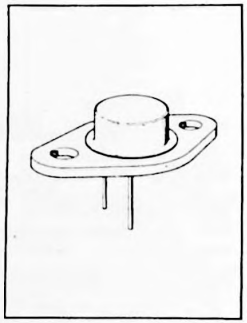
2N3766
2N3767

MEDIUM POWER SILICON TRANSISTOR FOR USE IN DRIVER CIRCUITS, SWITCHING AND MEDIUM POWER AMPLIFIERS APPLICATIONS

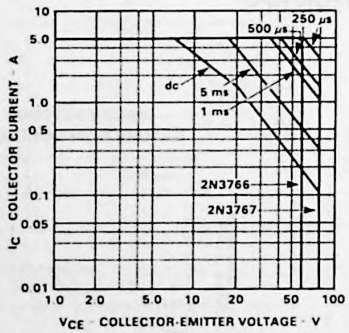
- 20 W DISSIPATION AT 25°C CASE
- 4.0 A MAXIMUM CONTINUOUS COLLECTOR CURRENT
- COMPLEMENT 2N3740, 2N3741

ABSOLUTE MAXIMUM RATINGS (Note 1)

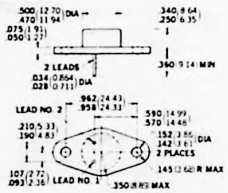
		2N3766	2N3767
Maximum Voltages and Currents			
V_{CEO}	Collector to Emitter Voltage	60 V	80 V
V_{CBO}	Collector to Base Voltage	80 V	100 V
V_{EBO}	Emitter to Base Voltage	6.0 V	6.0 V
I_C	Continuous Collector Current	4.0 A	4.0 A
I_B	Continuous Base Current	2.5 A	2.5 A
Maximum Power Dissipation			
P_D	Total Dissipation @ 25°C Case Temperature		20 W
	Derate Linearly from 25°C		0.133 W/°C
Maximum Temperatures			
T_J, T_{stg}	Storage and Operation Junction Temperatures		−65°C to 175°C
Thermal Characteristics			
$R_{\theta JC}$	Thermal Resistance, Junction to Case		7.5°C/W



SAFE OPERATING AREA



JEDEC (TO-66) Outline



NOTES:
All dimensions in inches (bold) and millimeters (parentheses)
Pins are gold-plated kovar
Pins 1 and 2 electrically isolated from case
Case is third electrical connection
Nickel-plated steel base and cap
Package weight is 6.5 grams

ELECTRICAL CHARACTERISTICS (25°C Case Temperature unless otherwise noted)

SYMBOL	CHARACTERISTIC	2N3766		2N3767		UNIT	TEST CONDITIONS
		MIN	MAX	MIN	MAX		
OFF CHARACTERISTICS							
$V_{CEO(sus)}$	Collector-Emitter Sustaining Voltage (Note 1)	60		80		V	I_C = 100 mA, I_B = 0
I_{CEO}	Collector Cutoff Current		0.7			mA	V_{CE} = 60 V, I_B = 0
					0.7	mA	V_{CE} = 80 V, I_B = 0
I_{CEX}	Collector Cutoff Current		0.1			mA	V_{CE} = 80 V, V_{BE} = −1.5 V
					0.1	mA	V_{CE} = 100 V, V_{BE} = −1.5 V
			1.0			mA	V_{CE} = 50 V, V_{BE} = −1.5 V, T_C = 150°C
					1.0	mA	V_{CE} = 70 V, V_{BE} = −1.5 V, T_C = 150°C
I_{CBO}	Collector Cutoff Current		0.1			mA	V_{CB} = 80 V, I_E = 0
					0.1	mA	V_{CB} = 100 V, I_E = 0
I_{EBO}	Emitter Cutoff Current		0.75		0.75	mA.	V_{EB} = 6.0 V, I_C = 0
ON CHARACTERISTICS							
h_{FE}	DC Current Gain (Note 1)	30		30			I_C = 50 mA, V_{CE} = 10 V
		40	160	40	160		I_C = 500 mA, V_{CE} = 5.0 V
		20		20			I_C = 1.0 A, V_{CE} = 5.0 V
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage (Note 1)		1.0		1.0	V	I_C = 500 mA, I_B = 50 mA
			2.5		2.5	V	I_C = 1.0 A, I_B = 100 mA
$V_{BE(on)}$	Base-Emitter "On" Voltage (Note 1)		1.5		1.5	V	I_C = 1.0 A, V_{CE} = 10 V
DYNAMIC CHARACTERISTICS							
f_T	Current-Gain-Bandwidth Product	10		10		MHz	I_C = 500 mA, V_{CE} = 10 V
C_{ob}	Output Capacitance		50		50	pF	V_{CB} = 10 V, I_E = 0, f = 0.1 MHz
h_{fe}	Small Signal Current Gain	40		40			I_C = 100 mA, V_{CE} = 10 V, f = 1.0 kHz

NOTE: 1. Pulse conditions: Length = 300 μs, Duty Cycle = 2%.

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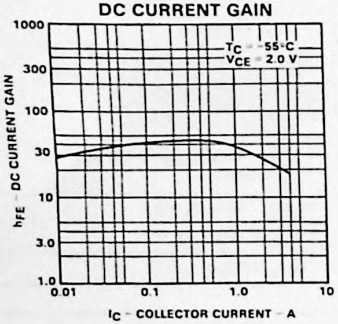
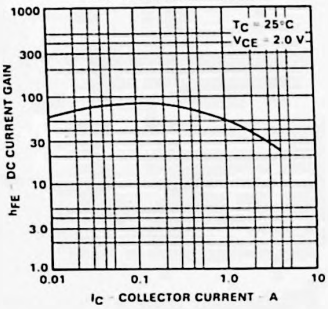
TYPICAL ELECTRICAL CHARACTERISTICS

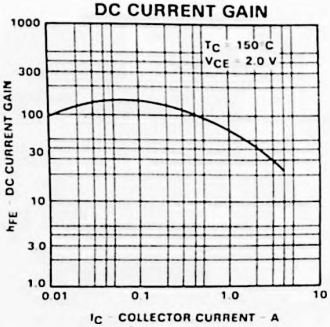
DC CURRENT GAIN



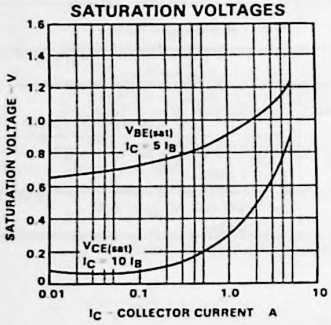
DC CURRENT GAIN



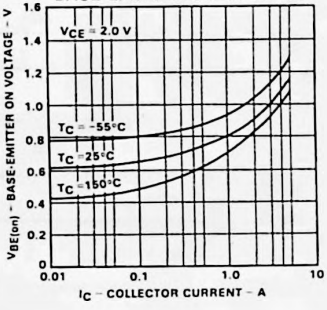
DC CURRENT GAIN



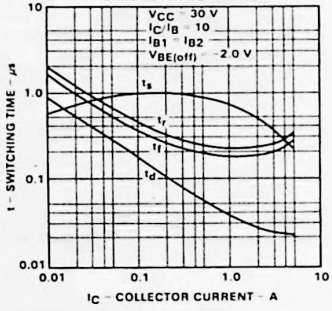
SATURATION VOLTAGES



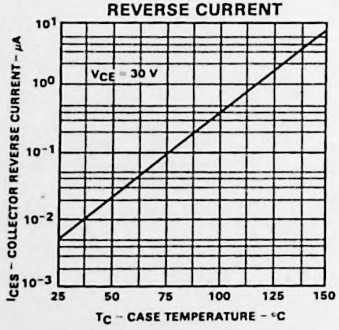
BASE-EMITTER ON VOLTAGE



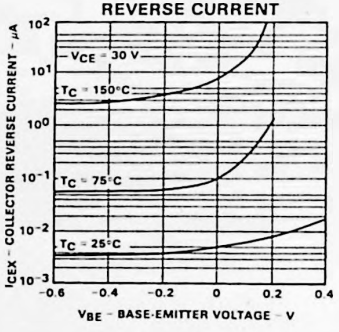
SWITCHING TIMES



COLLECTOR REVERSE CURRENT



COLLECTOR REVERSE CURRENT



POWER TRANSISTOR

NPN SILICON

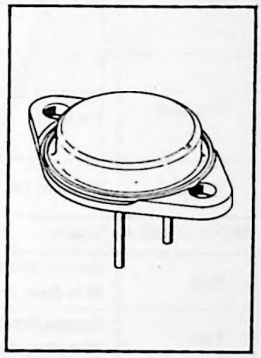
2N3771
2N3772

HIGH CURRENT, HIGH POWER DEVICES FOR USE IN AUDIO AMPLIFIERS, SERIES AND SHUNT REGULATOR DRIVER AND OUTPUT STAGES

- 150 W DISSIPATION AT 25°C CASE
- 30 A MAXIMUM CONTINUOUS COLLECTOR CURRENT
- LOW SATURATION VOLTAGE WITH HIGH BETA

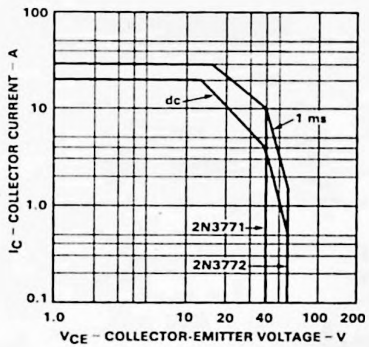
ABSOLUTE MAXIMUM RATINGS (Note 1)

		2N3771	2N3772
Maximum Voltages and Currents			
V_{CEO}	Collector to Emitter Voltage	40 V	60 V
V_{CBO}	Collector to Base Voltage	50 V	100 V
V_{EBO}	Emitter to Base Voltage	5.0 V	5.0 V
I_C	Continuous Collector Current	30 A	20 A
I_C	Peak Collector Current	30 A	30 A
I_B	Continuous Base Current	7.5 A	5.0 A
Maximum Power Dissipation			
P_D	Total Dissipation @25°C Case Temperature		150 W
	Derate Linearly from 25°C		0.857 W/°C
Maximum Temperatures			
T_J, T_{stg}	Storage and Operation Junction Temperatures		−65°C to +200°C
Thermal Characteristics			
$R_{\theta JC}$	Thermal Resistance, Junction to Case		1.17°C/W
T_P	Maximum Pin Temperature (Soldering, 5.0 s)		230°C

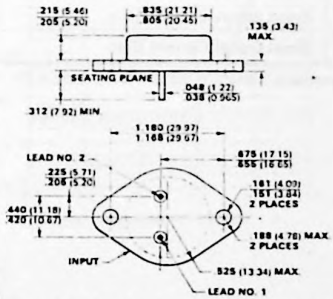


6

SAFE OPERATING AREA



JEDEC (TO-3) Outline



NOTES:
All dimensions in inches (bold) and millimeters (parentheses)
Pins are gold-plated or solder-dipped alloy 52
Pins 1 and 2 electrically isolated from case
Case is third electrical connection
Aluminum package with copper slug, pins are soldered in
Package weight is 7.4 grams
Aluminum cap

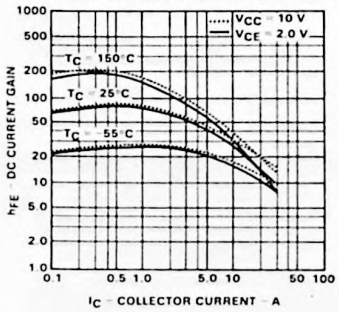
ELECTRICAL CHARACTERISTICS (25°C Case Temperature unless otherwise noted)

SYMBOL	CHARACTERISTIC	2N3771		2N3772		UNIT	TEST CONDITIONS
		MIN	MAX	MIN	MAX		
OFF CHARACTERISTICS							
$V_{CEO(sus)}$	Collector-Emitter Sustaining Voltage (Note 1)	40		60		V	I_C = 200 mA, I_B = 0
I_{CEO}	Collector Cutoff Current		10			mA	V_{CE} = 30 V, I_B = 0
					10	mA	V_{CE} = 50 V, I_B = 0
I_{CEX}	Collector Cutoff Current		2.0			mA	V_{CE} = 50 V, V_{BE} = −1.5 V
					5.0	mA	V_{CE} = 100 V, V_{BE} = −1.5 V
			10		10	mA	V_{CE} = 30 V, V_{BE} = −1.5 V, T_C = 150°C
I_{CBO}	Collector Cutoff Current		2.0			mA	V_{CB} = 50 V, I_E = 0
					5.0	mA	V_{CB} = 100 V, I_E = 0
I_{EBO}	Emitter Cutoff Current		5.0			mA	V_{EB} = 5.0 V, I_C = 0
					5.0	mA	V_{EB} = 7.0 V, I_C = 0
ON CHARACTERISTICS							
h_{FE}	DC Current Gain (Note 1)	15	60				I_C = 15 A, V_{CE} = 4.0 V
		5.0					I_C = 30 A, V_{CE} = 4.0 V
				15	60		I_C = 10 A, V_{CE} = 4.0 V
				5.0			I_C = 20 A, V_{CE} = 4.0 V
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage (Note 1)		2.0			V	I_C = 15 A, I_B = 1.5 A
			4.0			V	I_C = 30 A, I_B = 6.0 A
					1.4	V	I_C = 10 A, I_B = 1.0 A
					4.0	V	I_C = 20 A, I_B = 4.0 A
$V_{BE(on)}$	Base-Emitter "On" Voltage (Note 1)		2.7			V	I_C = 15 A, V_{CE} = 4.0 V
					2.2	V	I_C = 10 A, V_{CE} = 4.0 V
SECOND BREAKDOWN							
$I_{S/b}$	Second Breakdown Collector Current With Base Forward Biased	3.75				A	V_{CE} = 40 V, t = 1.0 s (non-repetitive)
			2.5			A	V_{CE} = 60 V, t = 1.0 s (non-repetitive)
$E_{S/b}$	Second Breakdown Energy With Base Reversed Biased	500		500		mJ	I_C = 5.0 A, $V_{BE(off)}$ = −1.5 V, L = 40 mH, R_{BE} = 100 Ω
DYNAMIC CHARACTERISTICS							
$\|h_{fe}\|$	Magnitude of Common Emitter Small Signal Current Gain	4.0		4.0			I_C = 1.0 A, V_{CE} = 4.0 V, f = 50 kHz
h_{fe}	Small Signal Current Gain	40		40			I_C = 1.0 A, V_{CE} = 4.0 V, f = 1.0 kHz

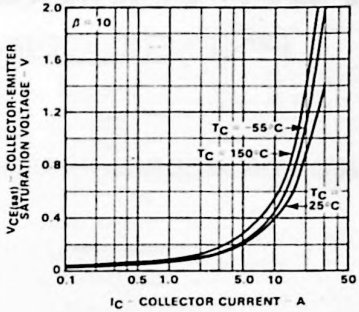
NOTE: 1. Pulse conditions: Length = 300 μs, Duty Cycle = 2%.

TYPICAL ELECTRICAL CHARACTERISTICS

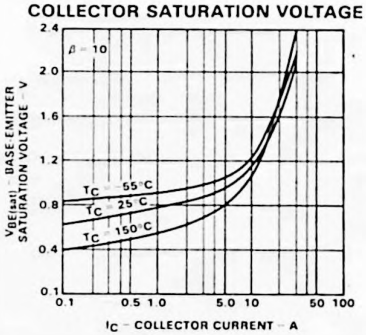
DC CURRENT GAIN



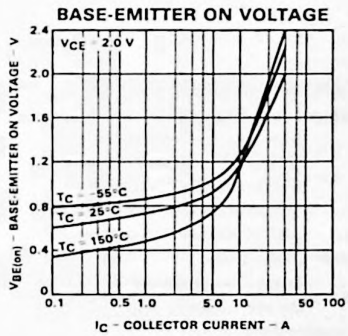
BASE SATURATION VOLTAGE



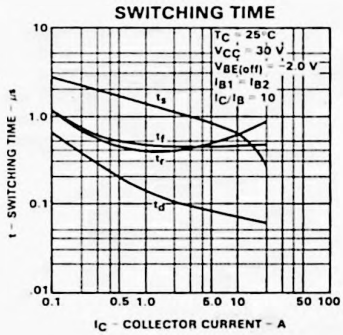
COLLECTOR SATURATION VOLTAGE



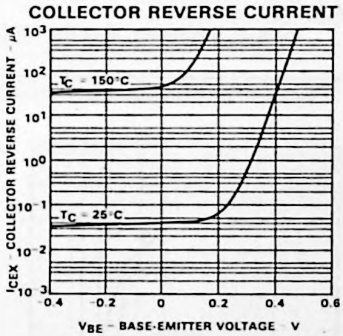
BASE-EMITTER ON VOLTAGE



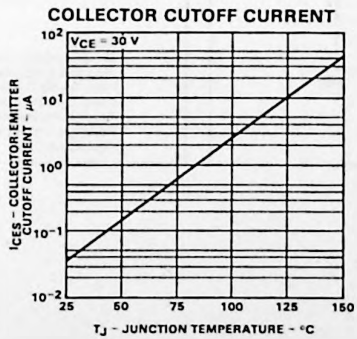
SWITCHING TIME



COLLECTOR REVERSE CURRENT



COLLECTOR CUTOFF CURRENT



POWER TRANSISTOR

PNP SILICON

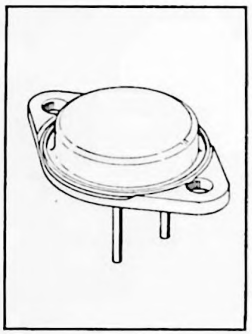
2N3789
2N3790
2N3791
2N3792

DESIGNED FOR MEDIUM-SPEED SWITCHING AND AMPLIFIER APPLICATIONS

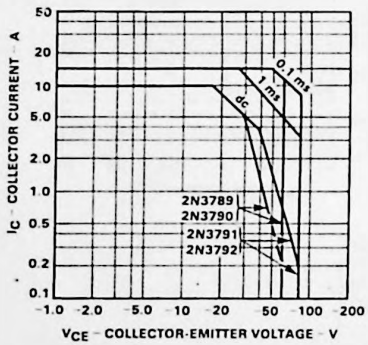
- 150 W DISSIPATION AT 25°C CASE
- 10 A MAXIMUM CONTINUOUS COLLECTOR CURRENT
- COMPLEMENTS 2N3713 THRU 2N3716

ABSOLUTE MAXIMUM RATINGS (Note 1)

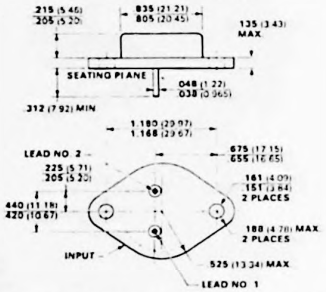
		2N3789	2N3790	2N3791	2N3792
Maximum Voltages and Currents					
V_{CEO}	Collector to Emitter Voltage	−60 V	−80 V	−60 V	−80 V
V_{CBO}	Collector to Base Voltage	−60 V	−80 V	−60 V	−80 V
V_{EBO}	Emitter to Base Voltage	−7.0 V	−7.0 V	−7.0 V	−7.0 V
I_C	Continuous Collector Current	10 A	10 A	10 A	10 A
I_B	Continuous Base Current	4.0 A	4.0 A	4.0 A	4.0 A
Maximum Power Dissipation					
P_D	Total Dissipation @ 25°C Case Temperature				150 W
	Derate Linearly from 25°C				0.86 W/°C
Maximum Temperatures					
T_J, T_{stg}	Storage and Operation Junction Temperatures				−65°C to 200°C
Thermal Characteristics					
$R_{\theta JC}$	Thermal Resistance, Junction to Case				1.17°C/W



SAFE OPERATING AREA



JEDEC (TO-3) Outline



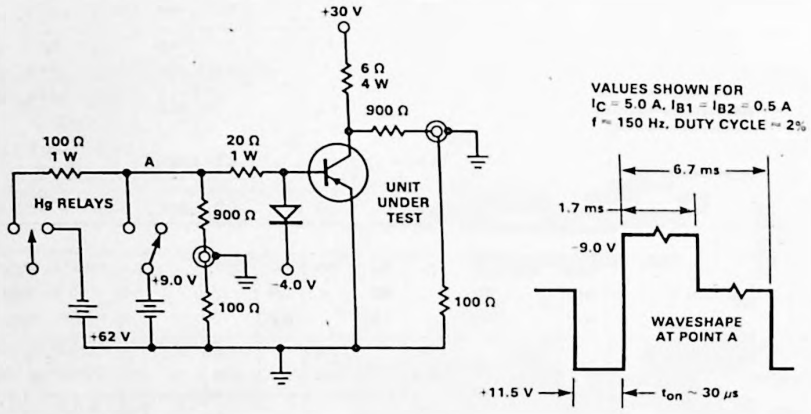
NOTES:
All dimensions in inches (bold) and millimeters (parentheses)
Pins are gold-plated or solder-dipped alloy 52
Pins 1 and 2 electrically isolated from case
Case is third electrical connection
Aluminum package with copper slug, pins are soldered in
Package weight is 7.4 grams
Aluminum cap

ELECTRICAL CHARACTERISTICS (25°C Case Temperature unless otherwise noted)

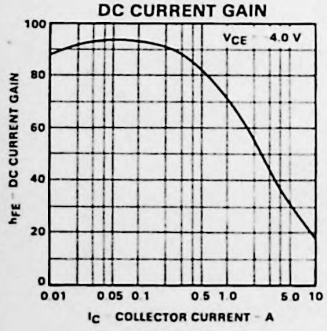
SYMBOL	CHARACTERISTIC	2N3789		2N3790		2N3791		2N3792		UNIT	TEST CONDITIONS
		MIN	MAX	MIN	MAX	MIN	MAX	MIN	MAX		
OFF CHARACTERISTICS											
$V_{CEO(sus)}$	Collector-Emitter Sustaining Voltage (Note 1)	-60		-80		-60		-80		V	I_C = 200 mA, I_B = 0
I_{CEO}	Collector Cutoff Current		10				10			mA	V_{CE} = -30 V, I_B = 0
					10				10	mA	V_{CE} = -40 V, I_B = 0
I_{CEX}	Collector Cutoff Current		1.0				1.0			mA	V_{CE} = -60 V, V_{BE} = 1.5 V
					1.0				1.0	mA	V_{CE} = -80 V, V_{BE} = 1.5 V
			5.0				5.0			mA	V_{CE} = -60 V, V_{BE} = 1.5 V, T_C = 150°C
					5.0				5.0	mA	V_{CE} = -80 V, V_{BE} = 1.5 V, T_C = 150°C
I_{EBO}	Emitter Cutoff Current		5.0		5.0		5.0		5.0	mA	V_{EB} = -7.0 V, I_C = 0
ON CHARACTERISTICS											
h_{FE}	DC Current Gain (Note 1)	25	90	25	90	50	150	50	150		I_C = 1.0 A, V_{CE} = -2.0 V
		15		15		30		30			I_C = 3.0 A, V_{CE} = -2.0 V
		4.0		4.0		4.0		4.0			I_C = 10 A, V_{CE} = -4.0 V
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage (Note 1)		-1.0		-1.0		-1.0		-1.0	V	I_C = 5.0 A, I_B = 0.5 A
			-4.0		-4.0		-4.0		-4.0	V	I_C = 10 A, I_B = 2.0 A
$V_{BE(sat)}$	Base-Emitter Saturation Voltage (Note 1)		-2.0		-2.0					V	I_C = 4.0 A, I_B = 0.4 A
							-1.5		-1.5	V	I_C = 5.0 A, I_B = 0.5 A
$V_{BE(on)}$	Base-Emitter "On" Voltage (Note 1)		-2.0		-2.0		-1.8		-1.8	V	I_C = 5.0 A, V_{CE} = -2.0 V
			-4.0		-4.0		-4.0		-4.0	V	I_C = 10 A, V_{CE} = -4.0 V
DYNAMIC CHARACTERISTICS											
C_{ob}	Output Capacitance		500		500		500		500	pF	V_{CB} = -10 V, I_E = 0, f = 0.1 MHz
h_{fe}	Magnitude of Common Emitter Small Signal Current Gain	4.0		4.0		4.0		4.0			I_C = 500 mA, V_{CE} = -10 V, f = 1.0 MHz
h_{fe}	Small Signal Current Gain	25	250	25	250	25	250	25	250		I_C = 500 mA, V_{CE} = -10 V, f = 1.0 kHz
f_{hfe}	Small Signal Cutoff Frequency	30		30		30		30		kHz	I_C = 500 mA, V_{CE} = -10 V

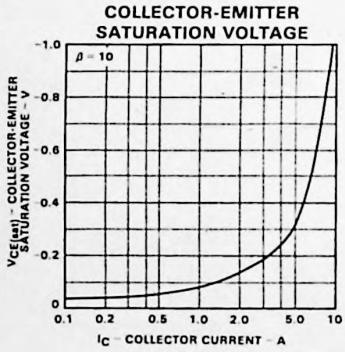
NOTE: 1. Pulse conditions: Length = 300 μs, Duty Cycle = 2%.

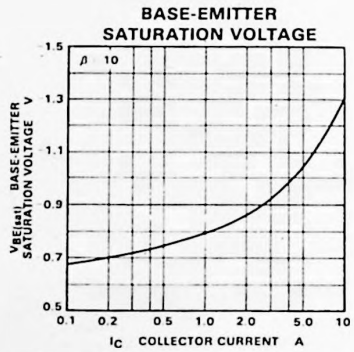
TEST CIRCUIT



TYPICAL ELECTRICAL CHARACTERISTICS

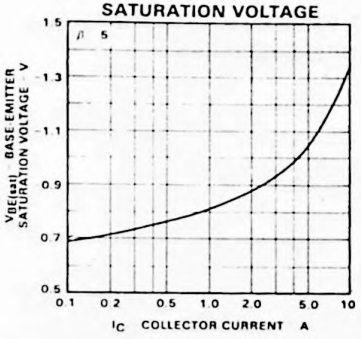




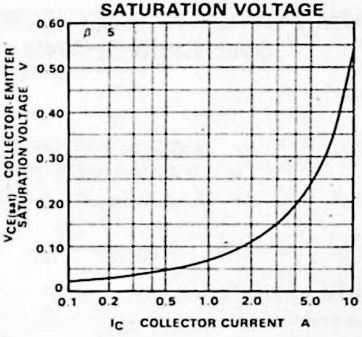


TYPICAL ELECTRICAL CHARACTERISTICS (Cont'd)

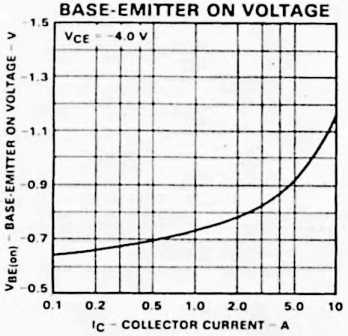
BASE-EMITTER SATURATION VOLTAGE



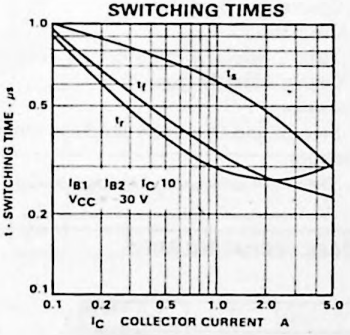
COLLECTOR-EMITTER SATURATION VOLTAGE



BASE-EMITTER ON VOLTAGE



SWITCHING TIMES



POWER TRANSISTOR

NPN SILICON

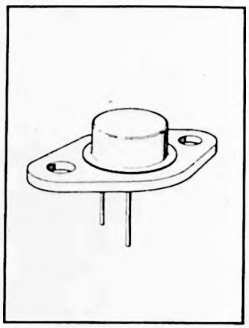
2N4231
2N4232
2N4233

MEDIUM POWER TRANSISTORS DESIGNED FOR DRIVER CIRCUITS, SWITCHING, AND AMPLIFIER APPLICATIONS

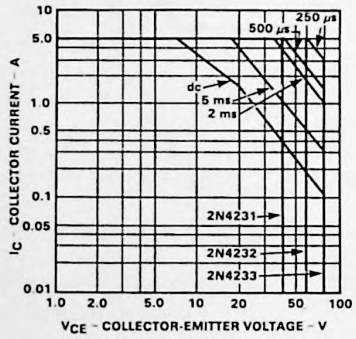
- 35 W DISSIPATION AT 25°C CASE
- 3.0 A MAXIMUM CONTINUOUS COLLECTOR CURRENT
- 25 - 100 h_{FE} @ 1.5 A, 2.0 V

ABSOLUTE MAXIMUM RATINGS (Note 1)

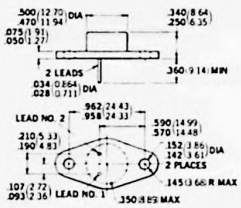
		2N4231	2N4232	2N4233
Maximum Voltages and Currents				
V_{CEO}	Collector to Emitter Voltage	40 V	60 V	80 V
V_{CBO}	Collector to Base Voltage	40 V	60 V	80 V
V_{EBO}	Emitter to Base Voltage	5.0 V	5.0 V	5.0 V
I_C	Continuous Collector Current	3.0 A	3.0 A	3.0 A
I_B	Continuous Base Current	1.0 A	1.0 A	1.0 A
Maximum Power Dissipation				
P_D	Total Dissipation @ 25°C Case Temperature			35 W
	Derate Linearly from 25°C			0.2 W/°C
Maximum Temperatures				
T_J, T_{stg}	Storage and Operation Junction Temperatures			−65°C to +200°C
Thermal Characteristics				
$R_{\theta JC}$	Thermal Resistance, Junction to Case			5.0°C/W



SAFE OPERATING AREA



JEDEC (TO-66) Outline



NOTES:
All dimensions in inches (bold) and millimeters (parentheses)
Pins are gold-plated kovar
Pins 1 and 2 electrically isolated from case
Case is third electrical connection
Nickel-plated steel base and cap
Package weight is 6.5 grams

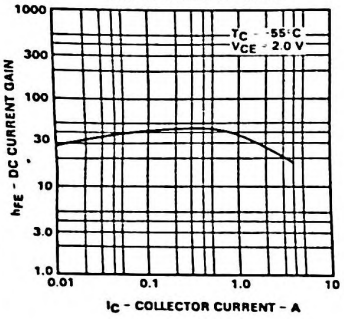
ELECTRICAL CHARACTERISTICS (25°C Case Temperature unless otherwise noted)

SYMBOL	CHARACTERISTIC	2N4231		2N4232		2N4233		UNIT	TEST CONDITIONS
		MIN	MAX	MIN	MAX	MIN	MAX		
OFF CHARACTERISTICS									
$V_{CEO(sus)}$	Collector-Emitter Sustaining Voltage (Note 1)	40		60		80		V	I_C = 100 mA, I_B = 0
I_{CEO}	Collector Cutoff Current		1.0		1.0		1.0	mA mA mA	V_{CE} = 30 V, I_B = 0 V_{CE} = 50 V, I_B = 0 V_{CE} = 70 V, I_B = 0
I_{CEX}	Collector Cutoff Current		0.1 1.0		0.1 1.0		0.1 1.0	mA mA mA mA mA	V_{CE} = 40 V, V_{BE} = −1.5 V V_{CE} = 60 V, V_{BE} = −1.5 V V_{CE} = 80 V, V_{BE} = −1.5 V V_{CE} = 40 V, V_{BE} = −1.5 V, T_C = 150°C V_{CE} = 60 V, V_{BE} = −1.5 V, T_C = 150°C V_{CE} = 80 V, V_{BE} = −1.5 V, T_C = 150°C
I_{CBO}	Collector Cutoff Current		50		50		50	μA μA μA	V_{CB} = 40 V, I_E = 0 V_{CB} = 60 V, I_E = 0 V_{CB} = 80 V, I_E = 0
I_{EBO}	Emitter Cutoff Current		500		500		500	μA	V_{EB} = 5.0 V, I_C = 0
ON CHARACTERISTICS									
h_{FE}	DC Current Gain (Note 1)	40 25 10	100	40 25 10	100	40 25 10	100		I_C = 0.5 A, V_{CE} = 2.0 V I_C = 1.5 A, V_{CE} = 2.0 V I_C = 3.0 A, V_{CE} = 2.0 V
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage (Note 1)		0.7 2.0		0.7 2.0		0.7 2.0	V V	I_C = 1.5 A, I_B = 150 mA I_C = 3.0 A, I_B = 300 mA
$V_{BE(on)}$	Base-Emitter "On" Voltage (Note 1)		1.4		1.4		1.4	V	I_C = 1.5 A, V_{CE} = 2.0 V
DYNAMIC CHARACTERISTICS									
C_{ob}	Output Capacitance		200		200		200	pF	V_{CB} = 10 V, I_E = 0, f = 0.1 MHz
h_{fe}	Small Signal Current Gain	20		20		20			I_C = 500 mA, V_{CE} = 10 V, f = 1.0 kHz

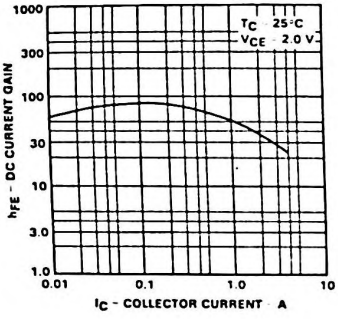
NOTE: Pulse Condition; Length = 300 μs, Duty Cycle = 2%

TYPICAL ELECTRICAL CHARACTERISTICS

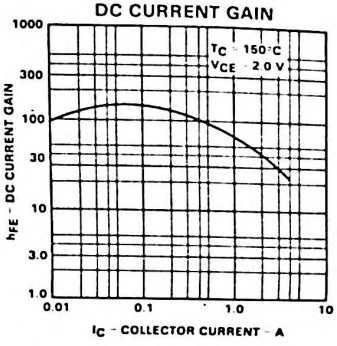
DC CURRENT GAIN



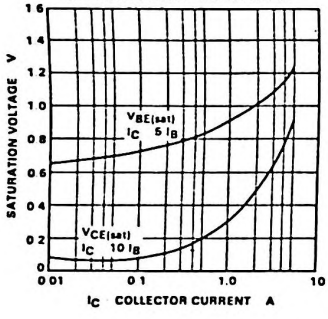
DC CURRENT GAIN



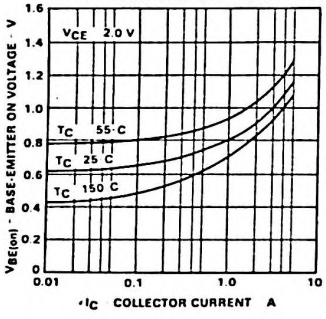
DC CURRENT GAIN



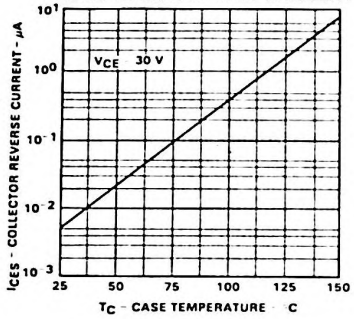
SATURATION VOLTAGES



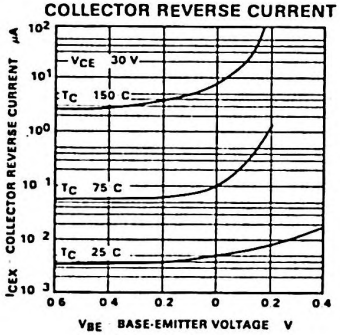
BASE-EMITTER ON VOLTAGE



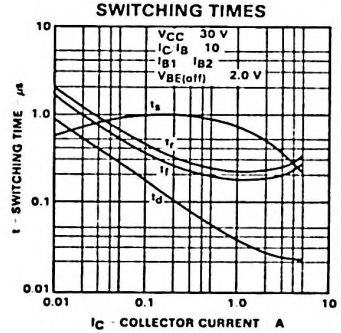
COLLECTOR REVERSE CURRENT



COLLECTOR REVERSE CURRENT



SWITCHING TIMES



POWER TRANSISTOR

PNP SILICON

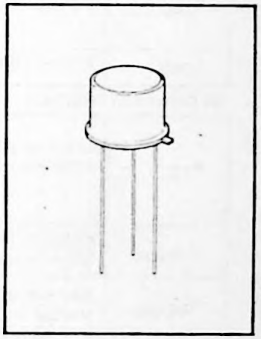
2N4234
2N4235
2N4236

DESIGNED FOR DRIVER CIRCUITS AND SWITCHING AND AMPLIFIER APPLICATIONS. IDEAL FOR DIRECT REPLACEMENT OF GERMANIUM MEDIUM POWER DEVICES.

- 6.0 W DISSIPATION AT 25°C CASE
- 3.0 A MAXIMUM CONTINUOUS COLLECTOR CURRENT
- COMPLEMENT TO 2N4237, 2N4238, 2N4239

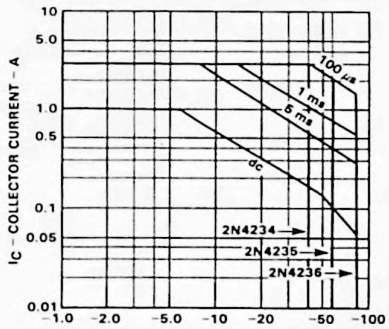
ABSOLUTE MAXIMUM RATINGS (Note 1)

		2N4234	2N4235	2N4236
Maximum Voltages and Currents				
V_{CEO}	Collector to Emitter Voltage	−40 V	−60 V	−80 V
V_{CBO}	Collector to Base Voltage	−40 V	−60 V	−80 V
V_{EBO}	Emitter to Base Voltage	−7.0 V	−7.0 V	−7.0 V
I_C	Continuous Collector Current	3.0 A	3.0 A	3.0 A
I_B	Continuous Base Current	0.2 A	0.2 A	0.2 A
Maximum Power Dissipation				
P_D	Total Dissipation @ 25°C Case Temperature			6.0 W
	Derate Linearly from 25°C			0.4 W/°C
Maximum Temperatures				
T_J, T_{stg}	Storage and Operation Junction Temperatures			−65°C to +175°C
Thermal Characteristics				
$R_{\theta JC}$	Thermal Resistance, Junction to Case			25°C/W

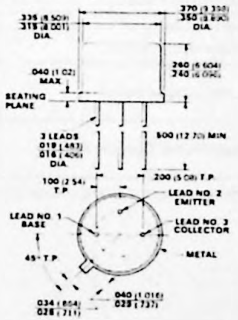


6

SAFE OPERATING AREA



JEDEC (TO-39) Outline



NOTES:
All dimensions in inches (bold) and millimeters (parentheses)
Leads are gold-plated kovar
Lead No. 3 connected to case
Package weight is 0.76 gram

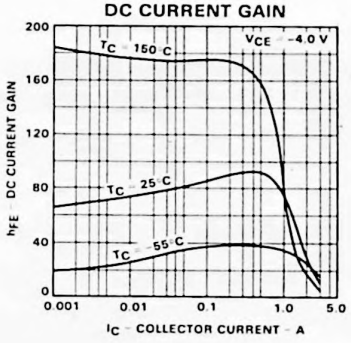
ELECTRICAL CHARACTERISTICS (25°C Case Temperature unless otherwise noted)

SYMBOL	CHARACTERISTIC	2N4234		2N4235		2N4236		UNIT	TEST CONDITIONS
		MIN	MAX	MIN	MAX	MIN	MAX		
OFF CHARACTERISTICS									
$V_{CEO(sus)}$	Collector-Emitter Sustaining Voltage (Note 1)	−40		−60		−80		V	I_C = 100 mA, I_B = 0
I_{CEO}	Collector Cutoff Current		1.0					mA	V_{CE} = −30 V, I_B = 0
					1.0			mA	V_{CE} = −40 V, I_B = 0
							1.0	mA	V_{CE} = −60 V, I_B = 0
I_{CEX}	Collector Cutoff Current		0.1					mA	V_{CE} = −40 V, V_{BE} = 1.5 V
					0.1			mA	V_{CE} = −60 V, V_{BE} = 1.5 V
							0.1	mA	V_{CE} = −80 V, V_{BE} = 1.5 V
			1.0					mA	V_{CE} = −30 V, V_{BE} = 1.5 V, T_C = 150°C
					1.0			mA	V_{CE} = −40 V, V_{BE} = 1.5 V, T_C = 150°C
							1.0	mA	V_{CE} = −60 V, V_{BE} = 1.5 V, T_C = 150°C
I_{CBO}	Collector Cutoff Current		0.1					mA	V_{CB} = −40 V, I_E = 0
					0.1			mA	V_{CB} = −60 V, I_E = 0
							0.1	mA	V_{CB} = −80 V, I_E = 0
I_{EBO}	Emitter Cutoff Current		0.5		0.5		0.5	mA	V_{EB} = −7.0 V, I_C = 0
ON CHARACTERISTICS									
h_{FE}	DC Current Gain (Note 1)	40		40		40			I_C = 100 mA, V_{CE} = −1.0 V
		30	150	30	150	30	150		I_C = 250 mA, V_{CE} = −1.0 V
		20		20		20			I_C = 500 mA, V_{CE} = −1.0 V
		10		10		10			I_C = 1.0 A, V_{CE} = −1.0 V
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage (Note 1)		−0.6		−0.6		−0.6	V	I_C = 1.0 A, I_B = 125 mA
$V_{BE(sat)}$	Base-Emitter Saturation Voltage (Note 1)		−1.5		−1.5		−1.5	V	I_C = 1.0 A, I_B = 0.1 A
$V_{BE(on)}$	Base-Emitter "On" Voltage (Note 1)		−1.0		−1.0		−1.0	V	I_C = 250 mA, V_{CE} = −1.0 V
DYNAMIC CHARACTERISTICS									
f_T	Current-Gain-Bandwidth Product	3.0		3.0		3.0		MHz	I_C = 100 mA, V_{CE} = −10 V, f = 1.0 MHz
C_{ob}	Output Capacitance		100		100		100	pF	V_{CB} = −10 V, I_E = 0, f = 100 kHz
h_{fe}	Small Signal Current Gain	25		25		25			I_C = 50 mA, V_{CE} = −10 V, f = 100 kHz

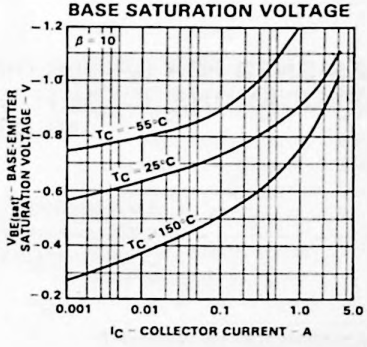
NOTE: 1. Pulse conditions: Length = 300 μs, Duty Cycle = 2%.

TYPICAL ELECTRICAL CHARACTERISTICS

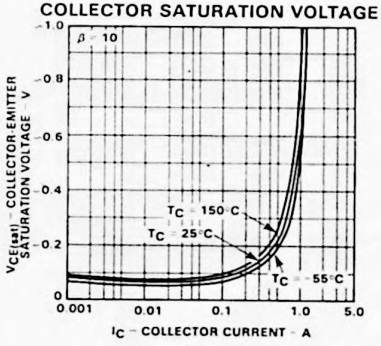
DC CURRENT GAIN



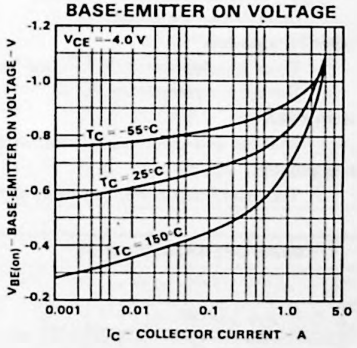
BASE SATURATION VOLTAGE



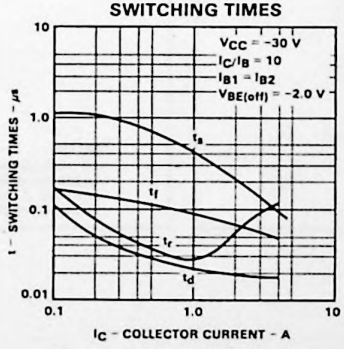
COLLECTOR SATURATION VOLTAGE



BASE-EMITTER ON VOLTAGE



SWITCHING TIMES



POWER TRANSISTOR

NPN SILICON

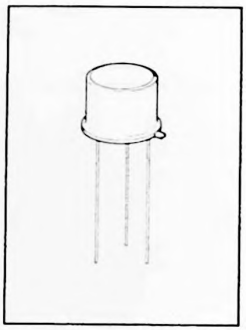
2N4237
2N4238
2N4239

DESIGNED FOR DRIVER CIRCUITS AND SWITCHING AND AMPLIFIER APPLICATIONS. IDEAL FOR DIRECT REPLACEMENT OF GERMANIUM MEDIUM POWER DEVICE.

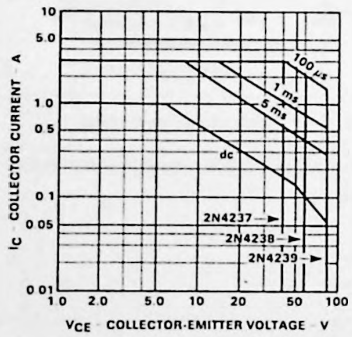
- 5.0 W DISSIPATION AT 25°C CASE
- 4.0 A MAXIMUM CONTINUOUS COLLECTOR CURRENT
- COMPLEMENT TO 2N4234, 2N4235, 2N4236

ABSOLUTE MAXIMUM RATINGS (Note 1)

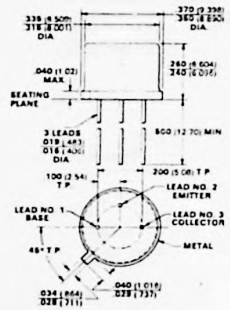
		2N4237	2N4238	2N4239
Maximum Voltages and Currents				
V_{CEO}	Collector to Emitter Voltage	40 V	60 V	80 V
V_{CBO}	Collector to Base Voltage	40 V	60 V	80 V
V_{EBO}	Emitter to Base Voltage	7.0 V	7.0 V	7.0 V
I_C	Continuous Collector Current	1.0 A	1.0 A	1.0 A
I_B	Continuous Base Current	0.2 A	0.2 A	0.2 A
Maximum Power Dissipation				
P_D	Total Dissipation @ 25°C Case Temperature			6.0 W
	Derate Linearly from 25°C			34.3 mW/°C
Maximum Temperatures				
T_J, T_{stg}	Storage and Operation Junction Temperatures			−65°C to +200°C
Thermal Characteristics				
$R_{\theta JC}$	Thermal Resistance, Junction to Case			29.2°C/W



SAFE OPERATING AREA



JEDEC (TO-39) Outline



NOTES:
All dimensions in inches (bold) and millimeters (parentheses)
Leads are gold-plated kovar
Lead No. 3 connected to case
Package weight is 0.76 gram

ELECTRICAL CHARACTERISTICS (25°C Case Temperature unless otherwise noted)

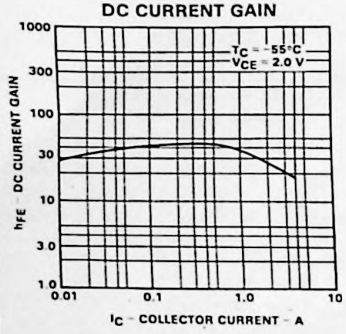
SYMBOL	CHARACTERISTIC	2N4237		2N4238		2N4239		UNIT	TEST CONDITIONS
		MIN	MAX	MIN	MAX	MIN	MAX		
OFF CHARACTERISTICS									
$V_{CEO(sus)}$	Collector-Emitter Sustaining Voltage (Note 1)	40		60		80		V	I_C = 100 mA, I_B = 0
I_{CEO}	Collector Cutoff Current		1.0					mA	V_{CE} = 40 V, I_B = 0
					1.0			mA	V_{CE} = 60 V, I_B = 0
							1.0	mA	V_{CE} = 80 V, I_B = 0
I_{CEX}	Collector Cutoff Current		0.1					mA	V_{CE} = 45 V, V_{BE} = −1.5 V
					0.1			mA	V_{CE} = 75 V, V_{BE} = −1.5 V
							0.1	mA	V_{CE} = 90 V, V_{BE} = −1.5 V
			1.0					mA	V_{CE} = 45 V, V_{BE} = −1.5 V, T_A = 150°C
					1.0			mA	V_{CE} = 75 V, V_{BE} = −1.5 V, T_A = 150°C
							1.0	mA	V_{CE} = 90 V, V_{BE} = −1.5 V, T_A = 150°C
I_{CBO}	Collector Cutoff Current		0.1					mA	V_{CB} = 50 V, I_E = 0
					0.1			mA	V_{CB} = 80 V, I_E = 0
							0.1	mA	V_{CB} = 100 V, I_E = 0
I_{EBO}	Emitter Cutoff Current		0.5		0.5		0.5	mA	V_{EB} = 6.0 V, I_C = 0
ON CHARACTERISTICS									
h_{FE}	DC Current Gain (Note 1)	30		30		30			I_C = 50 mA, V_{CE} = 1.0 V
		30	150	30	150	30	150		I_C = 250 mA, V_{CE} = 1.0 V
		30		30		30			I_C = 500 mA, V_{CE} = 4.0 V
		15		15		15			I_C = 1.0 A, V_{CE} = 1.0 V
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage (Note 1)		0.3		0.3		0.3	V	I_C = 500 mA, I_B = 50 mA
			0.6		0.6		0.6	V	I_C = 1.0 A, I_B = 100 mA
$V_{BE(sat)}$	Base-Emitter Saturation Voltage (Note 1)		1.5		1.5		1.5	V	I_C = 1.0 A, I_B = 100 mA
$V_{BE(on)}$	Base-Emitter "On" Voltage (Note 1)		1.0		1.0		1.0	V	I_C = 250 mA, V_{CE} = 1.0 V
DYNAMIC CHARACTERISTICS									
f_T	Current-Gain-Bandwidth Product	2.0		2.0		2.0		MHz	I_C = 100 mA, V_{CE} = 10 V, f = 1.0 MHz
C_{ob}	Output Capacitance		100		100		100	pF	V_{CB} = 10 V, I_E = 0, f = 0.1 MHz
h_{fe}	Small Signal Current Gain	30		30		30			I_C = 100 mA, V_{CE} = 10 V, f = 1.0 kHz

NOTE: 1. Pulse conditions: Length = 300 μs, Duty Cycle = 2%.

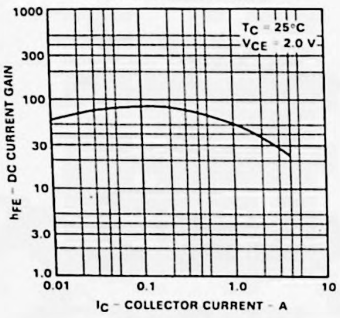
6

TYPICAL ELECTRICAL CHARACTERISTICS

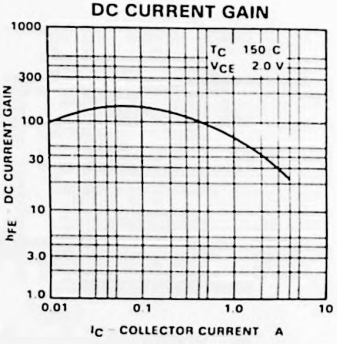
DC CURRENT GAIN



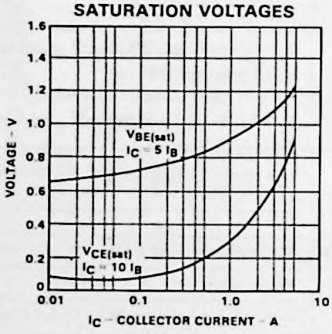
DC CURRENT GAIN



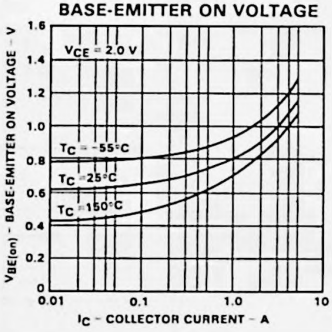
DC CURRENT GAIN



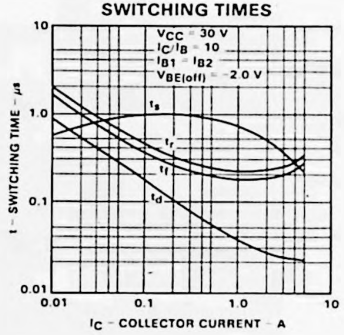
SATURATION VOLTAGES



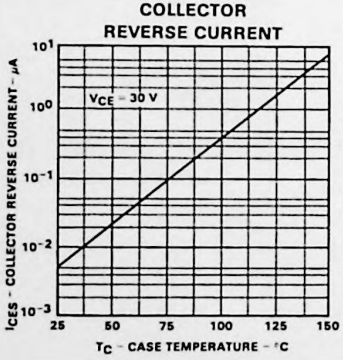
BASE-EMITTER ON VOLTAGE



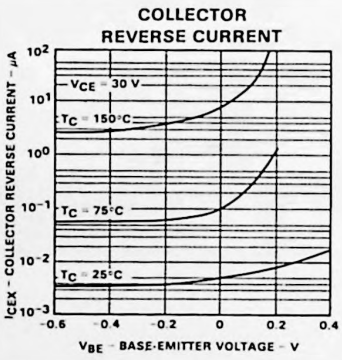
SWITCHING TIMES



COLLECTOR REVERSE CURRENT



COLLECTOR REVERSE CURRENT



POWER TRANSISTOR

PNP SILICON

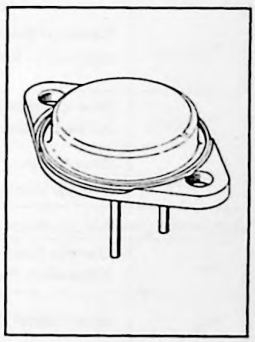
2N4398
2N4399

DESIGNED FOR USE IN POWER AMPLIFIER AND SWITCHING CIRCUITS
SERVES AS DIRECT REPLACEMENT FOR
GERMANIUM HIGH POWER DEVICES

- 200 W DISSIPATION AT 25°C CASE
- 30 A MAXIMUM CONTINUOUS COLLECTOR CURRENT
- COMPLEMENT TO 2N5301, 2N5302

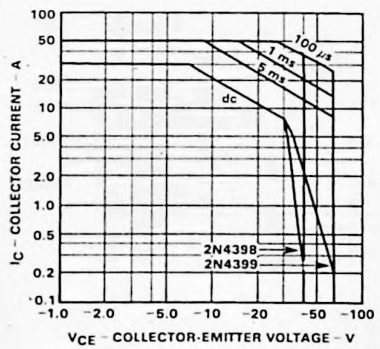
ABSOLUTE MAXIMUM RATINGS (Note 1)

		2N4398	2N4399
Maximum Voltages and Currents			
V_{CEO}	Collector to Emitter Voltage	-40 V	-60 V
V_{CBO}	Collector to Base Voltage	-40 V	-60 V
V_{EBO}	Emitter to Base Voltage	-5.0 V	-5.0 V
I_C	Continuous Collector Current	30 A	30 A
I_B	Continuous Base Current	7.5 A	7.5 A
Maximum Power Dissipation			
P_D	Total Dissipation A 25°C Case Temperature		200 W
	Derate Linearly from 25°C		1.14 W/°C
Maximum Temperatures			
T_J, T_{stg}	Storage and Operation Junction Temperatures		-65°C to +200°C
Thermal Characteristics			
$R_{\theta JC}$	Thermal Resistance, Junction to Case		0.875°C/W

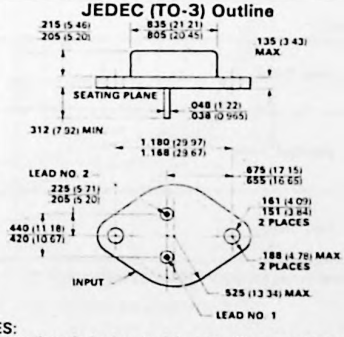


6

SAFE OPERATING AREA



JEDEC (TO-3) Outline



NOTES:
All dimensions in inches (bold) and millimeters (parentheses)
Pins are gold-plated or solder-dipped alloy 52
Pins 1 and 2 electrically isolated from case
Case is third electrical connection
Aluminum package with copper slug, pins are soldered in
Package weight is 7.4 grams
Aluminum cap

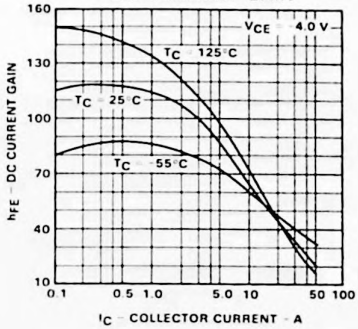
ELECTRICAL CHARACTERISTICS (25°C Case Temperature unless otherwise noted)

SYMBOL	CHARACTERISTIC	2N4398		2N4399		UNIT	TEST CONDITIONS
		MIN	MAX	MIN	MAX		
OFF CHARACTERISTICS							
$V_{CEO(sus)}$	Collector-Emitter Sustaining Voltage (Note 1)	−40		−60		V	I_C = 200 mA, I_B = 0
I_{CEO}	Collector Cutoff Current		5.0			mA	V_{CE} = −40 V, I_B = 0
					5.0	mA	V_{CE} = −60 V, I_B = 0
I_{CEX}	Collector Cutoff Current		5.0			mA	V_{CE} = −40 V, V_{BE} = 1.5 V
					5.0	mA	V_{CE} = −60 V, V_{BE} = 1.5 V
			10		10	mA	V_{CE} = −30 V, V_{BE} = 1.5 V, T_C = 150°C
I_{CBO}	Collector Cutoff Current		1.0			mA	V_{CB} = −40 V, I_E = 0
					1.0	mA	V_{CB} = −60 V, I_E = 0
I_{EBO}	Emitter Cutoff Current		5.0		5.0	mA	V_{EB} = −5.0 V, I_C = 0
ON CHARACTERISTICS							
h_{FE}	DC Current Gain (Note 1)	5.0		5.0			I_C = 30 A, V_{CE} = −4.0 V
		15	60	15	60		I_C = 15 A, V_{CE} = −4.0 V
		40		40			I_C = 1.0 A, V_{CE} = −2.0 V
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage (Note 1)		−4.0		−4.0	V	I_C = 30 A, I_B = 6.0 A
			−0.75		−0.75	V	I_C = 10 A, I_B = 1.0 A
			−1.0		−1.0	V	I_C = 15 A, I_B = 1.5 A
$V_{BE(sat)}$	Base-Emitter Saturation Voltage (Note 1)		−1.85		1.85	V	I_C = 15 A, I_B = 1.5 A
$V_{BE(on)}$	Base-Emitter "On" Voltage (Note 1)		−3.0		−3.0	V	I_C = 30 A, V_{CE} = −4.0 V
			−1.8		−1.8	V	I_C = 15 A, V_{CE} = −2.0 V
DYNAMIC CHARACTERISTICS							
f_T	Current-Gain-Bandwidth Product	4.0		4.0		MHz	I_C = 1.0 A, V_{CE} = −10 V, f = 1.0 MHz
h_{fe}	Small Signal Current Gain	40		40			I_C = 1.0 A, V_{CE} = −10 V, f = 1.0 kHz
SWITCHING CHARACTERISTICS							
RESISTIVE LOAD							
t_r	Rise Time		0.4		0.4	μs	V_{CC} = −30 V, I_C = 10 A, I_{B1} = 1.0 A, t_p = 10 to 100 μs, Duty Cycle 2%
t_s	Storage Time		1.5		1.5	μs	V_{CC} = −30 V, I_C = 10 A, I_{B1} = I_{B2} = 1.0 A, t_p = 10 to 100 μs, Duty Cycle = 2%
t_f	Fall Time		0.6		0.6	μs	V_{CC} = −30 V, I_C = 10 A, I_{B1} = I_{B2} = 1.0 A, t_p = 10 to 100 μs, Duty Cycle 2%

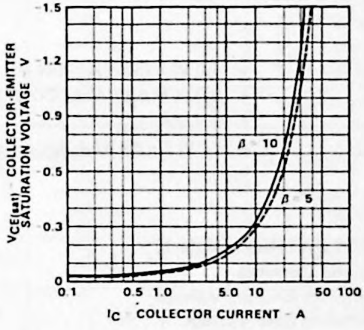
NOTE: 1. Pulse conditions: Length = 300 μs, Duty Cycle = 2%.

TYPICAL ELECTRICAL CHARACTERISTICS

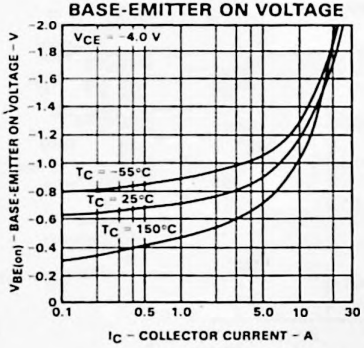
DC CURRENT GAIN



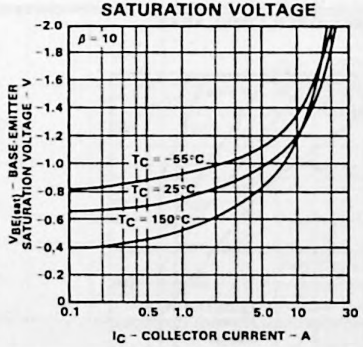
COLLECTOR-EMITTER SATURATION VOLTAGE



BASE-EMITTER ON VOLTAGE



BASE-EMITTER SATURATION VOLTAGE



POWER TRANSISTOR

NPN SILICON

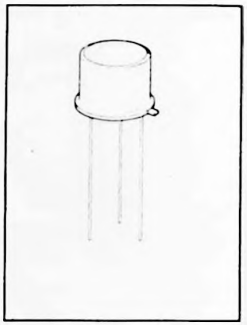
2N4895
2N4896
2N4897

DESIGNED AS GENERAL PURPOSE MEDIUM POWER DEVICE

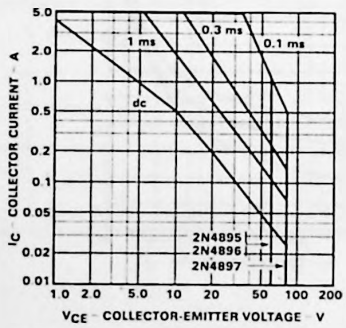
- 4.0 W DISSIPATION AT 25°C CASE
- 5.0 A MAXIMUM CONTINUOUS COLLECTOR CURRENT
- 0.7 $V_{CE(sat)}$ AT 2.0 A
- LOW LEAKAGE $I_{CES(MAX)}$ 100 μA @ T_C = 150°C

ABSOLUTE MAXIMUM RATINGS (Note 1)

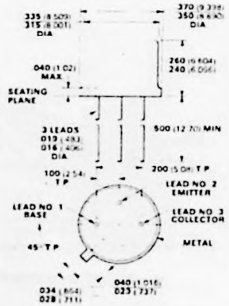
		2N4895	2N4896	2N4897
Maximum Voltages and Currents				
V_{CEO}	Collector to Emitter Voltage	60 V	60 V	80 V
V_{CBO}	Collector to Base Voltage	120 V	120 V	120 V
V_{EBO}	Emitter to Base Voltage	6.0 V	6.0 V	6.0 V
I_C	Continuous Collector Current	5.0 A	5.0 A	5.0 A
I_B	Continuous Base Current	1.0 A	1.0 A	1.0 A
Maximum Power Dissipation				
P_D	Total Dissipation @ 25°C Case Temperature			4.0 W
	Derate Linearly from 25°C			22.9 mW/°C
Maximum Temperatures				
T_J, T_{stg}	Storage and Operation Junction Temperatures			−65°C to +200°C
Thermal Characteristics				
$R_{\theta JC}$	Thermal Resistance, Junction to Case			43.8°C/W



SAFE OPERATING AREA



JEDEC (TO-39) Outline



NOTES:
All dimensions in inches (bold) and millimeters (parentheses)
Leads are gold-plated kovar
Lead No. 3 connected to case
Package weight is 1.23 grams

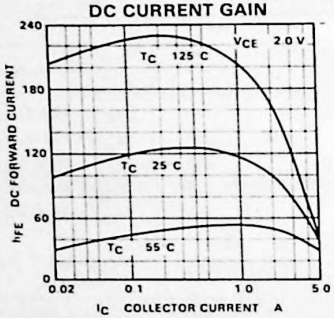
ELECTRICAL CHARACTERISTICS (25°C Case Temperature unless otherwise noted)

SYMBOL	CHARACTERISTIC	2N4895		2N4896		2N4897		UNIT	TEST CONDITIONS
		MIN	MAX	MIN	MAX	MIN	MAX		
OFF CHARACTERISTICS									
$V_{CEO(sus)}$	Collector-Emitter Sustaining Voltage (Note 1)	60		60		80		V	I_C = 50 mA, I_B = 0
I_{CES}	Collector Reverse Current		1.0		1.0			mA	V_{CE} = 120 V, V_{BE} = 0
							1.0	mA	V_{CE} = 150 V, V_{BE} = 0
			1.0		1.0			mA	V_{CE} = 60 V, V_{BE} = 0
							1.0	mA	V_{CE} = 100 V, V_{BE} = 0
			0.1		0.1			mA	V_{CE} = 60 V, V_{BE} = 0, T_C = 150°C
							0.1	mA	V_{CE} = 100 V, V_{BE} = 0, T_C = 150°C
I_{EBO}	Emitter Cutoff Current		1.0		1.0		1.0	mA	V_{EB} = 4.0 V, I_C = 0
ON CHARACTERISTICS									
h_{FE}	DC Current Gain (Note 1)	40	120	100	300	40	120		I_C = 2.0 A, V_{CE} = 2.0 V
		15		35		15			I_C = 2.0 A, V_{CE} = 2.0 V, T_C = −55°C
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage (Note 1)		1.0		1.0		1.0	V	I_C = 5.0 A, I_B = 5.0 A
$V_{BE(sat)}$	Base-Emitter Saturation Voltage (Note 1)		1.6		1.6		1.6	V	I_C = 5.0 A, I_B = 0.5 A
DYNAMIC CHARACTERISTICS									
C_{ob}	Output Capacitance		80		80		80	pF	V_{CB} = 10 V, I_E = 0, f = 0.14 MHz
C_{ib}	Input Capacitance		500		500		500	pF	V_{EB} = 0.5 V, I_C = 0, f = 0.14 MHz
$\|h_{fe}\|$	Magnitude of Common Emitter Small Signal Current Gain	2.5		4.0		2.5			I_C = 0.5 A, V_{CE} = 5.0 V, f = 20 MHz
SWITCHING CHARACTERISTICS									
RESISTIVE LOAD									
t_d	Delay Time		50		50		50	μs	V_{CC} = 20 V, I_C = 5.0 A, I_{B1} = 0.5 A, t_p = 10 μs, Duty Cycle 1%
t_r	Rise Time		300		300		300	μs	
t_s	Storage Time		350		350		350	μs	V_{CC} = 20 V, I_C = 5.0 A, I_{B1} = I_{B2} = 0.5 A, t_p = 10 μs, Duty Cycle 1%
t_f	Fall Time		300		300		300	μs	

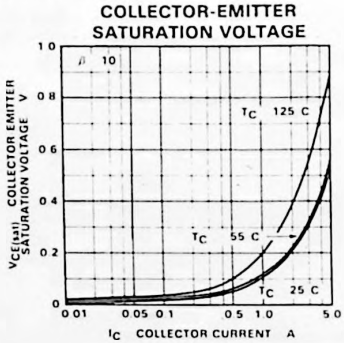
NOTE: 1. Pulse conditions: Length = 300 μs, Duty Cycle = 2%.

TYPICAL ELECTRICAL CHARACTERISTICS

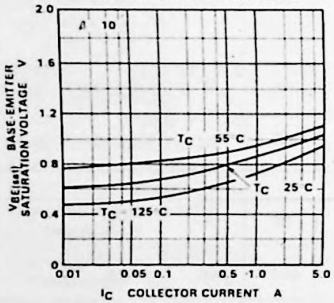
DC CURRENT GAIN



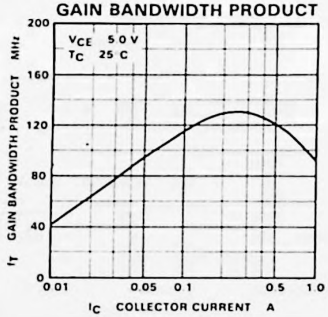
COLLECTOR-EMITTER SATURATION VOLTAGE



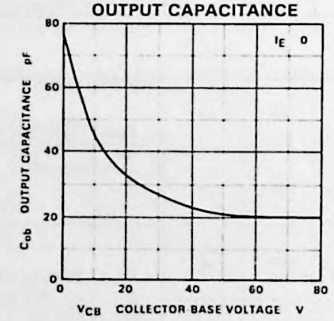
BASE-EMITTER SATURATION VOLTAGE



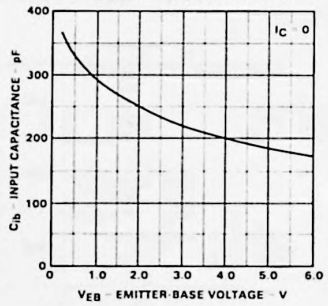
GAIN BANDWIDTH PRODUCT



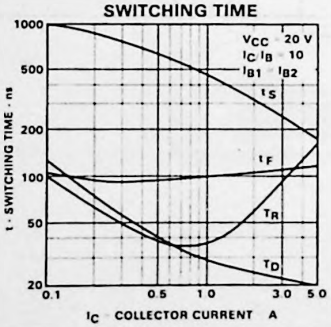
OUTPUT CAPACITANCE



INPUT CAPACITANCE



SWITCHING TIME



POWER TRANSISTOR

PNP SILICON

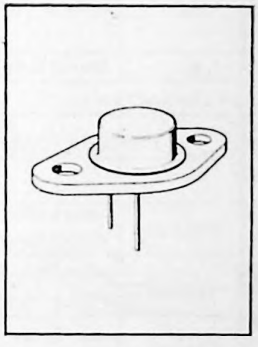
2N4898
2N4899
2N4900

MEDIUM POWER DEVICE DESIGNED FOR DRIVER CIRCUITS, SWITCHING AND AMPLIFIER APPLICATIONS

- 25 W DISSIPATION AT 25°C CASE
- 4.0 A MAXIMUM CONTINUOUS COLLECTOR CURRENT
- COMPLEMENTS 2N4910, 2N4911, 2N4912

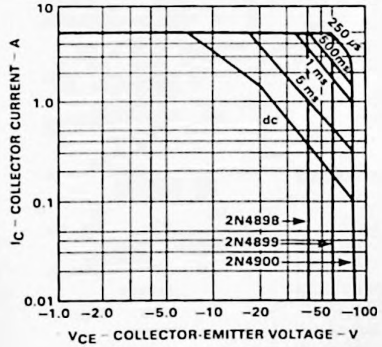
ABSOLUTE MAXIMUM RATINGS (Note 1)

		2N4898	2N4899	2N4900
Maximum Voltages and Currents				
V_{CEO}	Collector to Emitter Voltage	−40 V	−60 V	−80 V
V_{CBO}	Collector to Base Voltage	−40 V	−60 V	−80 V
V_{EBO}	Emitter to Base Voltage	−5.0 V	−5.0 V	−5.0 V
I_C	Continuous Collector Current	1.0 A	1.0 A	1.0 A
I_B	Continuous Base Current	1.0 A	1.0 A	1.0 A
Maximum Power Dissipation				
P_D	Total Dissipation @ 25°C Case Temperature			25 W
	Derate Linearly from 25°C			0.143 W/°C
Maximum Temperatures				
T_J, T_{stg}	Storage and Operation Junction Temperatures			−65°C to +200°C
Thermal Characteristics				
$R_{\theta JC}$	Thermal Resistance, Junction to Case			7.0°C/W

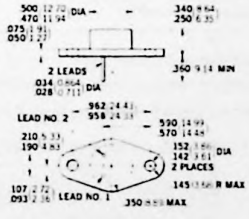


6

SAFE OPERATING AREA



JEDEC (TO-66) Outline



NOTES:
All dimensions in inches (bold) and millimeters (parentheses)
Pins are gold-plated kovar
Pins 1 and 2 electrically isolated from case
Case is third electrical connection
Nickel-plated steel base and cap
Package weight is 6.5 grams

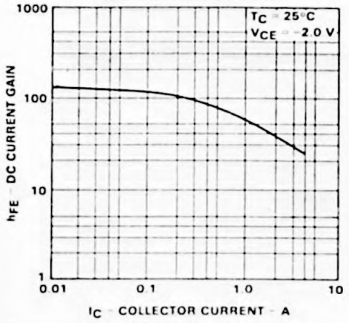
ELECTRICAL CHARACTERISTICS (25°C Case Temperature unless otherwise noted)

SYMBOL	CHARACTERISTIC	2N4898		2N4899		2N4900		UNIT	TEST CONDITIONS
		MIN	MAX	MIN	MAX	MIN	MAX		
OFF CHARACTERISTICS									
$V_{CEO(sus)}$	Collector-Emitter Sustaining Voltage (Note 1)	−40		−60		−80		V	I_C = 100 mA, I_B = 0
I_{CEO}	Collector Cutoff Current		0.5		0.5		0.5	mA mA mA	V_{CE} = −20 V, I_B = 0 V_{CE} = −30 V, I_B = 0 V_{CE} = −40 V, I_B = 0
I_{CEX}	Collector Cutoff Current		0.1 1.0		0.1 1.0		0.1 1.0	mA mA mA mA mA mA	V_{CE} = −40 V, V_{BE} = 1.5 V V_{CE} = −60 V, V_{BE} = 1.5 V V_{CE} = −80 V, V_{BE} = 1.5 V V_{CE} = −40 V, V_{BE} = 1.5 V, T_C = 150°C V_{CE} = −60 V, V_{BE} = 1.5 V, T_C = 150°C V_{CE} = −80 V, V_{BE} = 1.5 V, T_C = 150°C
I_{CBO}	Collector Cutoff Current		0.1		0.1		0.1	mA mA mA	V_{CB} = −40 V, I_E = 0 V_{CB} = −60 V, I_E = 0 V_{CB} = −80 V, I_E = 0
I_{EBO}	Emitter Cutoff Current		1.0		1.0		1.0	mA	V_{EB} = −5.0 V, I_C = 0
ON CHARACTERISTICS									
h_{FE}	DC Current Gain (Note 1)	10 20 40	100	10 20 40	100	10 20 40	100		I_C = 50 mA, V_{CE} = −1.0 V I_C = 500 mA, V_{CE} = −1.0 V I_C = 1.0 A, V_{CE} = −1.0 V
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage (Note 1)		−0.6		−0.6		−0.6	V	I_C = 1.0 A, I_B = 100 mA
$V_{BE(sat)}$	Base-Emitter Saturation Voltage (Note 1)		−1.3		−1.3		−1.3	V	I_C = 1.0 A, I_B = 100 mA
$V_{BE(on)}$	Base-Emitter "On" Voltage (Note 1)		−1.3		−1.3	−1.3		V	I_C = 1.0 A, V_{CE} = −1.0 V
DYNAMIC CHARACTERISTICS									
f_T	Current-Gain-Bandwidth Product	3.0		3.0		3.0		MHz	I_C = 200 mA, V_{CE} = −10 V, f = 1.0 MHz
C_{ob}	Output Capacitance		100		100		100	pF	V_{CB} = −10 V, I_E = 0, f = 0.1 MHz
h_{fe}	Small Signal Current Gain	25		25		25			I_C = 250 mA, V_{CE} = −10 V, f = 1.0 kHz

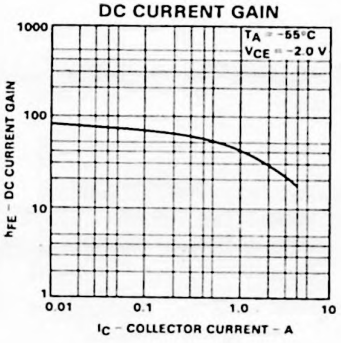
NOTE: Pulse Condition: Length = 300 μs, Duty Cycle = 2%

TYPICAL ELECTRICAL CHARACTERISTICS

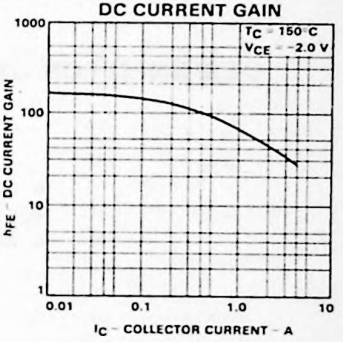
DC CURRENT GAIN



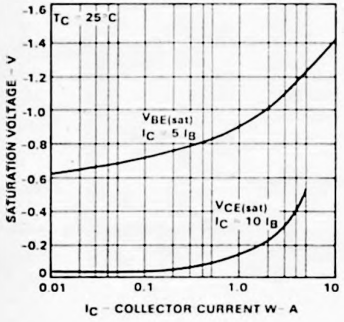
DC CURRENT GAIN



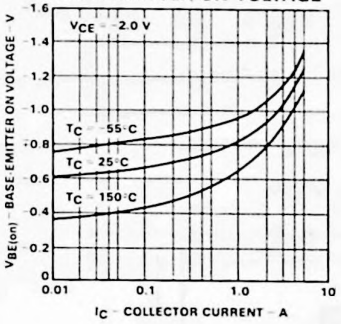
DC CURRENT GAIN



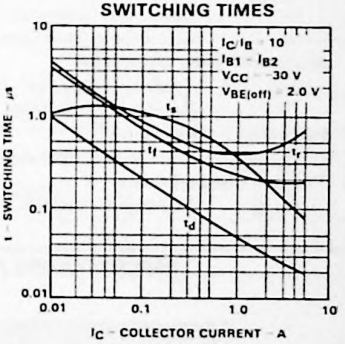
SATURATION VOLTAGES



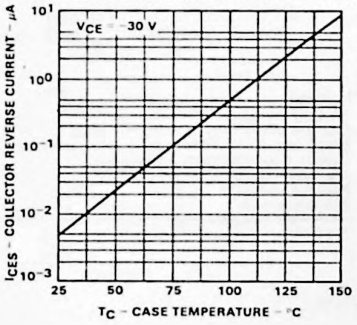
BASE-EMITTER ON VOLTAGE



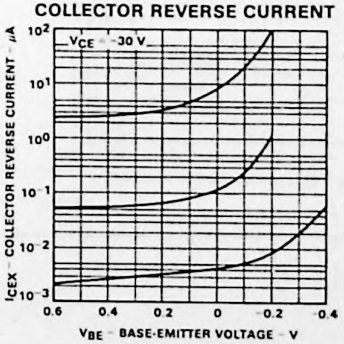
SWITCHING TIMES



COLLECTOR REVERSE CURRENT



COLLECTOR REVERSE CURRENT



6

POWER TRANSISTOR

PNP SILICON

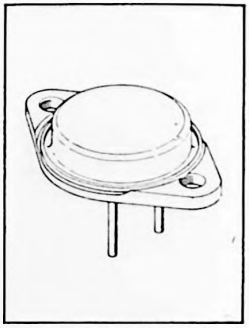
2N4901
2N4902
2N4903

DESIGNED FOR USE IN POWER AMPLIFIER AND SWITCHING CIRCUITS

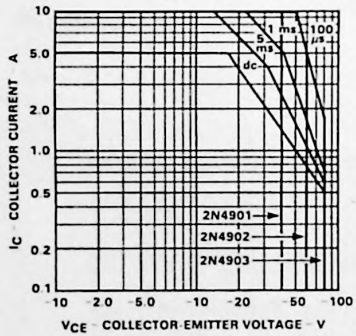
- 87.5 W DISSIPATION AT 25°C CASE
- 5.0 A MAXIMUM CONTINUOUS COLLECTOR CURRENT
- COMPLEMENTS TO 2N5067, 2N5068, 2N5069

ABSOLUTE MAXIMUM RATINGS (Note 1)

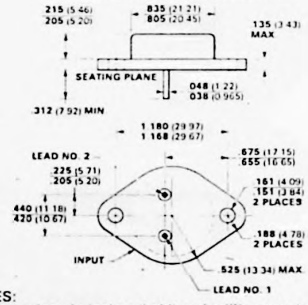
		2N4901	2N4902	2N4903
Maximum Voltages and Currents				
V_{CEO}	Collector to Emitter Voltage	–40 V	–60 V	–80 V
V_{CBO}	Collector to Base Voltage	–40 V	–60 V	–80 V
V_{EBO}	Emitter to Base Voltage	–5.0 V	–5.0 V	–5.0 V
I_C	Continuous Collector Current	5.0 A	5.0 A	5.0 A
I_B	Continuous Base Current	1.0 A	1.0 A	1.0 A
Maximum Power Dissipation				
P_D	Total Dissipation @ 25°C Case Temperature			87.5 W
	Derate Linearly from 25°C			0.5 W/°C
Maximum Temperatures				
T_J, T_{stg}	Storage and Operation Junction Temperatures			–65°C to +200°C
Thermal Characteristics				
$R_{\theta JC}$	Thermal Resistance, Junction to Case			2.0°C/W



SAFE OPERATING AREA



JEDEC (TO-3) Outline



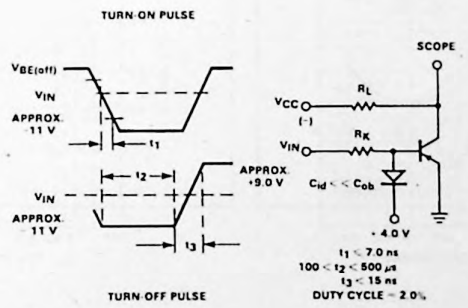
NOTES:
All dimensions in inches (bold) and millimeters (parentheses)
Pins are gold-plated or solder-dipped alloy 52
Pins 1 and 2 electrically isolated from case
Case is third electrical connection
Aluminum package with copper slug, pins are soldered in
Package weight is 7.4 grams
Aluminum cap

ELECTRICAL CHARACTERISTICS (25°C Case Temperature unless otherwise noted)

SYMBOL	CHARACTERISTIC	2N4901		2N4902		2N4903		UNIT	TEST CONDITIONS
		MIN	MAX	MIN	MAX	MIN	MAX		
OFF CHARACTERISTICS									
$V_{CEO(sus)}$	Collector-Emitter Sustaining Voltage (Note 1)	−40		−60		−80		V	I_C = 200 mA, I_B = 0
I_{CEO}	Collector Cutoff Current		1.0					mA	V_{CE} = −40 V, I_B = 0
					1.0			mA	V_{CE} = −60 V, I_B = 0
							1.0	mA	V_{CE} = −80 V, I_B = 0
I_{CEX}	Collector Cutoff Current		0.1					mA	V_{CE} = −40 V, V_{BE} = 1.5 V
					0.1			mA	V_{CE} = −60 V, V_{BE} = 1.5 V
							0.1	mA	V_{CE} = −80 V, V_{BE} = 1.5 V
			2.0					mA	V_{CE} = −40 V, V_{BE} = 1.5 V, T_C = 150°C
					2.0			mA	V_{CE} = −60 V, V_{BE} = 1.5 V, T_C = 150°C
							2.0	mA	V_{CE} = −80 V, V_{BE} = 1.5 V, T_C = 150°C
I_{CBO}	Collector Cutoff Current		0.1					mA	V_{CB} = −40 V, I_E = 0
					0.1			mA	V_{CB} = −60 V, I_E = 0
							0.1	mA	V_{CB} = −80 V, I_E = 0
I_{EBO}	Emitter Cutoff Current		1.0		1.0		1.0	mA	V_{EB} = − 5.0 V, I_C = 0
ON CHARACTERISTICS									
h_{FE}	DC Current Gain (Note 1)	20	80	20	80	20	80		I_C = 1.0 A, V_{CE} = −2.0 V
		7.0		7.0		7.0			I_C = 5.0 A, V_{CE} = −2.0 V
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage (Note 1)		−0.4		−0.4		−0.4	V	I_C = 1.0 A, I_B = 0.1 A
			−1.5		−1.5		−1.5	V	I_C = 5.0 A, I_B = 1.0 A
$V_{BE(on)}$	Base-Emitter "On" Voltage (Note 1)		−1.2		−1.2		−1.2	V	I_C = 1.0 A, V_{CE} = −2.0 V
DYNAMIC CHARACTERISTICS									
f_T	Current-Gain-Bandwidth Product	4.0		4.0		4.0		MHz	I_C = 1.0 A, V_{CE} = −10 V, f = 1.0 MHz
h_{fe}	Small Signal Current Gain	20		20		20			I_C = 0.5 A, V_{CE} = −10 V, f = 1.0 kHz

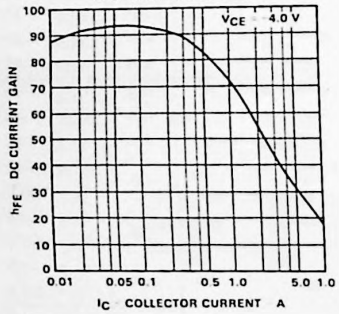
NOTE: 1. Pulse conditions: Length = 300 μs, Duty Cycle = 2%.

SWITCHING TIME EQUIVALENT CIRCUIT

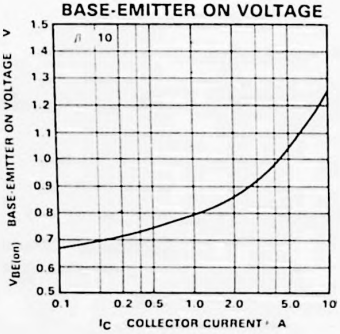


TYPICAL ELECTRICAL CHARACTERISTICS

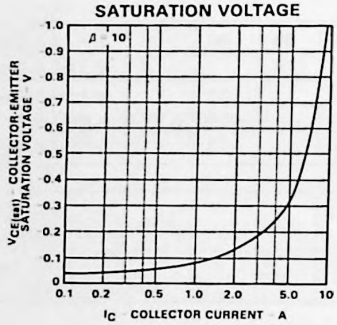
DC CURRENT GAIN



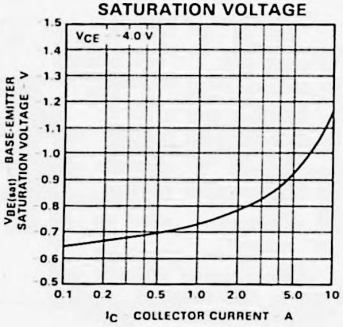
BASE-EMITTER ON VOLTAGE



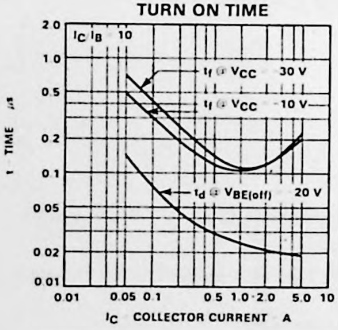
COLLECTOR-EMITTER SATURATION VOLTAGE



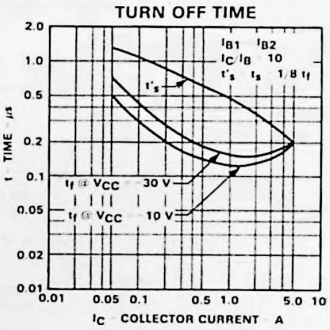
BASE-EMITTER SATURATION VOLTAGE



TURN ON TIME



TURN OFF TIME



POWER TRANSISTOR

PNP SILICON

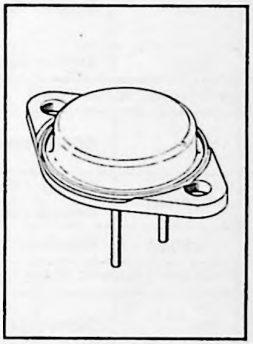
2N4904
2N4905
2N4906

DESIGNED FOR USE IN POWER AMPLIFIER AND SWITCHING CIRCUITS

- 87.5 W DISSIPATION AT 25°C CASE
- 5.0 A MAXIMUM CONTINUOUS COLLECTOR CURRENT
- COMPLEMENTS TO 2N4913, 2N4914, 2N4915

ABSOLUTE MAXIMUM RATINGS (Note 1)

		2N4904	2N4905	2N4906
Maximum Voltages and Currents				
V_{CEO}	Collector to Emitter Voltage	−40 V	−60 V	−80 V
V_{CBO}	Collector to Base Voltage	−40 V	−60 V	−80 V
V_{EBO}	Emitter to Base Voltage	−5.0 V	−5.0 V	−5.0 V
I_C	Continuous Collector Current	5.0 A	5.0 A	5.0 A
I_B	Continuous Base Current	1.0 A	1.0 A	1.0 A
Maximum Power Dissipation				
P_D	Total Dissipation @ 25°C Case Temperature			87.5 W
	Derate Linearly from 25°C			0.5 W/°C
Maximum Temperatures				
T_J, T_{stg}	Storage and Operation Junction Temperatures			−165°C to +200°C
Thermal Characteristics				
$R_{\theta JC}$	Thermal Resistance, Junction to Case			2.0°C/W



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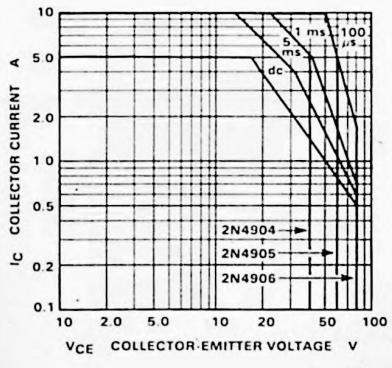
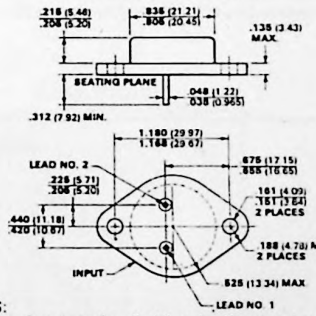
SAFE OPERATING AREA



JEDEC (TO-3) Outline



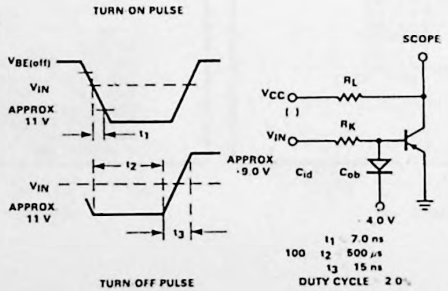
NOTES:
All dimensions in inches (bold) and millimeters (parentheses)
Pins are gold-plated or solder-dipped alloy 52
Pins 1 and 2 electrically isolated from case
Case is third electrical connection
Aluminum package with copper slug, pins are soldered in
Package weight is 7.4 grams
Aluminum cap

ELECTRICAL CHARACTERISTICS (25°C Case Temperature unless otherwise noted)

SYMBOL	CHARACTERISTIC	2N4904		2N4905		2N4906		UNIT	TEST CONDITIONS
		MIN	MAX	MIN	MAX	MIN	MAX		
OFF CHARACTERISTICS									
$V_{CEO(sus)}$	Collector-Emitter Sustaining Voltage (Note 1)	−40		−60		−80		V	I_C = 200 mA, I_B = 0
I_{CEO}	Collector Cutoff Current		1.0		1.0		1.0	mA	V_{CE} = −40 V, I_B = 0 V_{CE} = −60 V, I_B = 0 V_{CE} = −80 V, I_B = 0
I_{CEX}	Collector Cutoff Current		0.1		0.1		0.1	mA	V_{CE} = −40 V, V_{BE} = 1.5 V
								mA	V_{CE} = −60 V, V_{BE} = 1.5 V
								mA	V_{CE} = −80 V, V_{BE} = 1.5 V
			2.0					mA	V_{CE} = −40 V, V_{BE} = 1.5 V, T_C = 150°C
					2.0			mA	V_{CE} = −60 V, V_{BE} = 1.5 V, T_C = 150°C
							2.0	mA	V_{CE} = −80 V, V_{BE} = 1.5 V, T_C = 150°C
I_{CBO}	Collector Cutoff Current		0.1		0.1			mA	V_{CB} = −40 V, I_E = 0
								mA	V_{CB} = −60 V, I_E = 0
							0.1	mA	V_{CB} = −80 V, I_E = 0
I_{EBO}	Emitter Cutoff Current		1.0		1.0		1.0	mA	V_{EB} = 5.0 V, I_C = 0
ON CHARACTERISTICS									
h_{FE}	DC Current Gain (Note 1)	25	100	25	100	25	100		I_C = 2.5 A, V_{CE} = −2.0 V
		7.0		7.0		7.0			I_C = 5.0 A, V_{CE} = −2.0 V
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage (Note 1)		−1.5		−1.5		−1.5	V	I_C = 5.0 A, I_B = 1.0 A
$V_{BE(on)}$	Base-Emitter "On" Voltage (Note 1)		−1.4		−1.4		−1.4	V	I_C = 2.5 A, V_{CE} = −2.0 V
DYNAMIC CHARACTERISTICS									
f_T	Current-Gain-Bandwidth Product	4.0		4.0		4.0		MHz	I_C = 1.0 A, V_{CE} = −10 V, f = 1.0 MHz
h_{fe}	Small Signal Current Gain	40		40		40			I_C = 0.5 A, V_{CE} = −10 V, f = 1.0 kHz

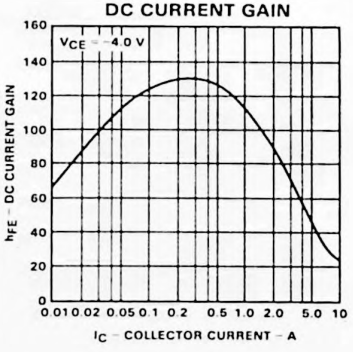
NOTE 1. Pulse conditions: Length = 300 μs, Duty Cycle = 2%.

SWITCHING TIME EQUIVALENT CIRCUIT

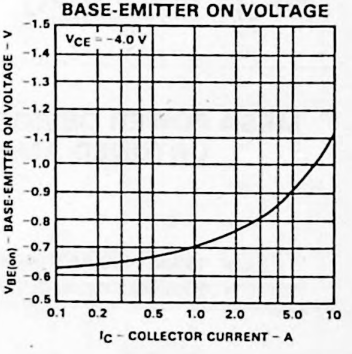


TYPICAL ELECTRICAL CHARACTERISTICS

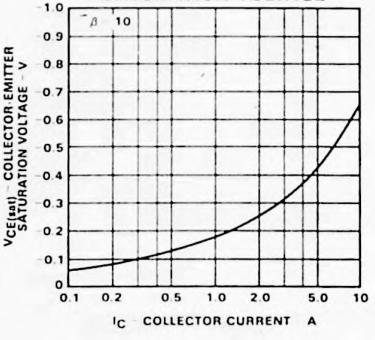
DC CURRENT GAIN



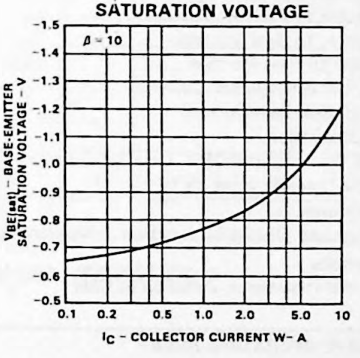
BASE-EMITTER ON VOLTAGE



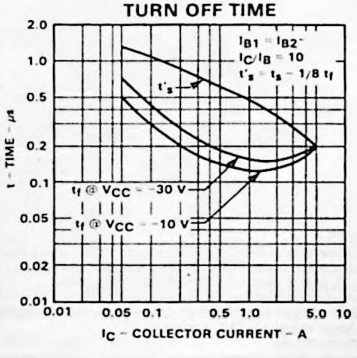
COLLECTOR-EMITTER SATURATION VOLTAGE



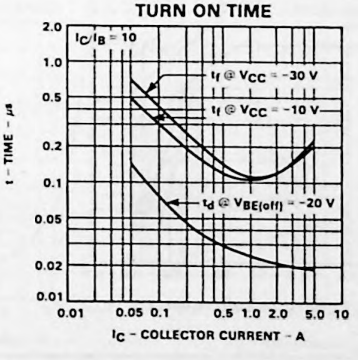
BASE-EMITTER SATURATION VOLTAGE



TURN OFF TIME



TURN ON TIME



6

POWER TRANSISTOR

PNP SILICON

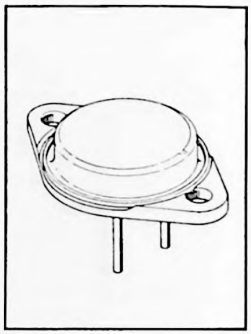
2N4907
2N4908
2N4909

MESA POWER DEVICE DESIGNED PRIMARILY FOR UNTUNED AMPLIFIER APPLICATIONS

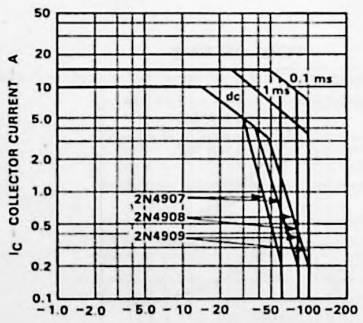
- 150 W DISSIPATION AT 25°C CASE
- 10 A MAXIMUM CONTINUOUS COLLECTOR CURRENT

ABSOLUTE MAXIMUM RATINGS (Note 1)

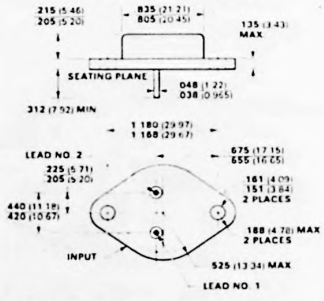
		2N4907	2N4908	2N4909
Maximum Voltages and Currents				
V_{CEO}	Collector to Emitter Voltage	-40 V	-60 V	-80 V
V_{CBO}	Collector to Base Voltage	-40 V	-60 V	-80 V
V_{EBO}	Emitter to Base Voltage	-5.0 V	-5.0 V	-5.0 V
I_C	Continuous Collector Current	10 A	10 A	10 A
I_B	Continuous Base Current	7.0 A	7.0 A	7.0 A
Maximum Power Dissipation				
P_D	Total Dissipation @ 25°C Case Temperature			150 W
	Derate Linearly from 25°C			0.86 W/°C
Maximum Temperatures				
T_J, T_{stg}	Storage and Operation Junction Temperatures			-65°C to +200°C
Thermal Characteristics				
$R_{\theta JC}$	Thermal Resistance, Junction to Case			1.17°C/W



SAFE OPERATING AREA



JEDEC (TO-3) Outline



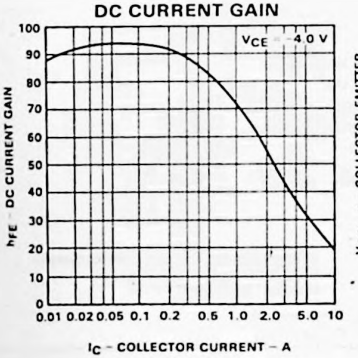
NOTES:
All dimensions in inches (bold) and millimeters (parentheses)
Pins are gold-plated or solder-dipped alloy 52
Pins 1 and 2 electrically isolated from case
Case is third electrical connection
Aluminum package with copper slug, pins are soldered in
Package weight is 7.4 grams
Aluminum cap

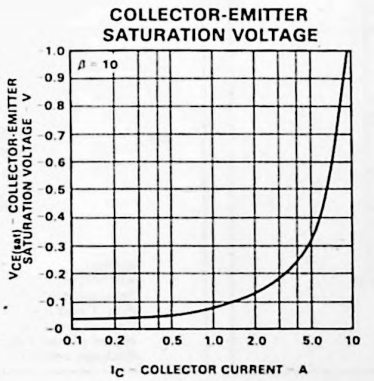
ELECTRICAL CHARACTERISTICS (25°C Case Temperature unless otherwise noted)

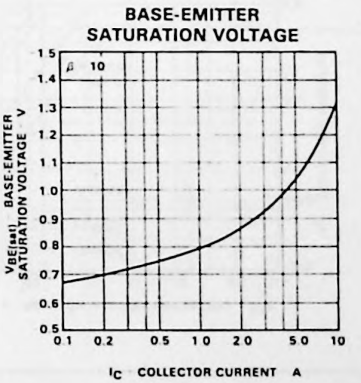
SYMBOL	CHARACTERISTIC	2N4907		2N4908		2N4909		UNITS	TEST CONDITIONS
		MIN	MAX	MIN	MAX	MIN	MAX		
OFF CHARACTERISTICS									
$V_{CEO(sus)}$	Collector-Emitter Sustaining Voltage (Note 1)	-40		-60		-80		V	I_C = 200 mA, I_B = 0
I_{CEO}	Collector Cutoff Current		0.7		0.7		0.7	mA mA mA	V_{CE} = -20 V, I_B = 0 V_{CE} = -30 V, I_B = 0 V_{CE} = -40 V, I_B = 0
I_{CEX}	Collector Cutoff Current		2.0 30		2.0 30		2.0 30	mA mA mA mA mA mA	V_{CE} = -40 V, V_{BE} = 1.5 V V_{CE} = -60 V, V_{BE} = 1.5 V V_{CE} = -80 V, V_{BE} = 1.5 V V_{CE} = -40 V, V_{BE} = 1.5 V, T_C = 150°C V_{CE} = -60 V, V_{BE} = 1.5 V, T_C = 150°C V_{CE} = -80 V, V_{BE} = 1.5 V, T_C = 150°C
I_{EBO}	Emitter Cutoff Current		5.0		5.0		5.0	mA	V_{EB} = -5.0 V, I_C = 0
ON CHARACTERISTICS									
h_{FE}	DC Current Gain (Note 1)	5.0 20	 80	5.0 20	 80	5.0 20	 80		I_C = 10 A, V_{CE} = -4.0 V I_C = 4.0 A, V_{CE} = -4.0 V
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage (Note 1)		-2.0 -0.75		-2.0 -0.75		-2.0 -0.75	V V	I_C = 10A, I_B = 2.0 A I_C = 4.0 A, I_B = 400 mA
$V_{BE(on)}$	Base-Emitter "On" Voltage (Note 1)		-1.5		-1.5		-1.5	V	I_C = 4.0 A, V_{CE} = -4.0 V
DYNAMIC CHARACTERISTICS									
C_{ob}	Output Capacitance		600		600		600	pF	V_{CB} = -10 V, I_E = 0, f = 0.1 MHz
$\|h_{fe}\|$	Magnitude of Common Emitter Small Signal Current Gain	4.0		4.0		4.0			I_C = 1.0 A, V_{CE} = -10 V, f = 1.0 MHz
h_{fe}	Small Signal Current Gain	15		15		15			I_C = 1.0 A, V_{CE} = -4.0 V, f = 1.0 kHz

NOTE: 1. Pulse conditions: Length = 300 μs, Duty Cycle = 2%.

TYPICAL ELECTRICAL CHARACTERISTICS







POWER TRANSISTOR

NPN SILICON

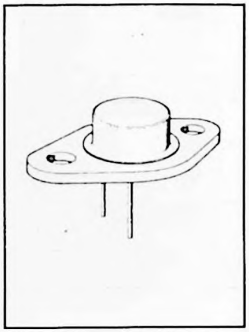
2N4910
2N4911
2N4912

MEDIUM POWER DEVICE DESIGNED FOR DRIVER CIRCUITS, SWITCHING AND AMPLIFIER APPLICATIONS

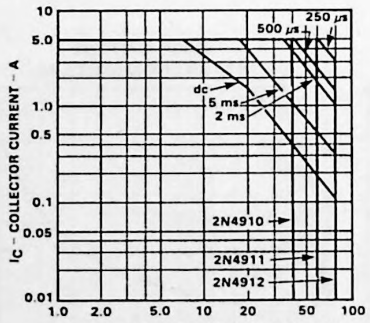
- 25 W DISSIPATION AT 25°C CASE
- 1.0 A MAXIMUM CONTINUOUS COLLECTOR CURRENT
- COMPLEMENT TO 2N4898, 2N4899, 2N4900

ABSOLUTE MAXIMUM RATINGS (Note 1)

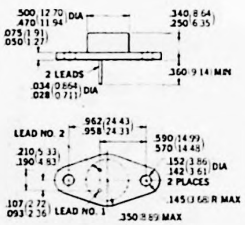
		2N4910	2N4911	2N4912
Maximum Voltages and Currents				
V_{CEO}	Collector to Emitter Voltage	40 V	60 V	80 V
V_{CBO}	Collector to Base Voltage	40 V	60 V	80 V
V_{EBO}	Emitter to Base Voltage	5.0 V	5.0 V	5.0 V
I_C	Continuous Collector Current	1.0 A	1.0 A	1.0 A
I_B	Continuous Base Current	1.0 A	1.0 A	1.0 A
Maximum Power Dissipation				
P_D	Total Dissipation @ 25°C Case Temperature			25 W
	Derate Linearly from 25°C			0.143 W/°C
Maximum Temperatures				
T_J, T_{stg}	Storage and Operation Junction Temperatures			−65°C to +200°C
Thermal Characteristics				
$R_{\theta JC}$	Thermal Resistance, Junction to Case			7.0°C/W



SAFE OPERATING AREA



JEDEC (TO-66) Outline



NOTES:
All dimensions in inches (bold) and millimeters (parentheses)
Pins are gold-plated kovar
Pins 1 and 2 electrically isolated from case
Case is third electrical connection
Nickel-plated steel base and cap
Package weight is 6.5 grams

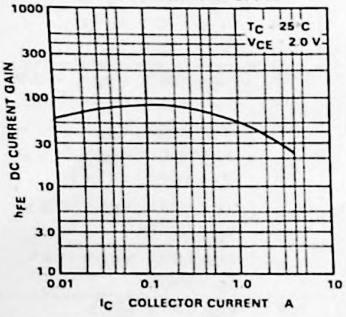
ELECTRICAL CHARACTERISTICS (25°C Case Temperature unless otherwise noted)

SYMBOL	CHARACTERISTIC	2N4910		2N4911		2N4912		UNIT	TEST CONDITIONS
		MIN	MAX	MIN	MAX	MIN	MAX		
OFF CHARACTERISTICS									
$V_{CEO(sus)}$	Collector-Emitter Sustaining Voltage (Note 1)	40		60		80		V	I_C = 100 mA, I_B = 0
I_{CEO}	Collector Cutoff Current		0.5		0.5		0.5	mA mA mA	V_{CE} = 20 V, I_B = 0 V_{CE} = 30 V, I_B = 0 V_{CE} = 40 V, I_B = 0
I_{CEX}	Collector Cutoff Current		0.1 1.0		0.1 1.0		0.1 1.0	mA mA mA mA mA mA	V_{CE} = 40 V, V_{BE} = −1.5 V V_{CE} = 60 V, V_{BE} = −1.5 V V_{CE} = 80 V, V_{BE} = −1.5 V V_{CE} = 40 V, V_{BE} = −1.5 V, T_C = 150°C V_{CE} = 60 V, V_{BE} = −1.5 V, T_C = 150°C V_{CE} = 80 V, V_{BE} = −1.5 V, T_C = 150°C
I_{CBO}	Collector Cutoff Current		0.1		0.1		0.1	mA mA mA	V_{CB} = 40 V, I_E = 0 V_{CB} = 60 V, I_E = 0 V_{CB} = 80 V, I_E = 0
I_{EBO}	Emitter Cutoff Current		1.0		1.0		1.0	mA	V_{EB} = 5.0 V, I_C = 0
ON CHARACTERISTICS									
h_{FE}	DC Current Gain (Note 1)	40 20 10	 100 	40 20 10	 100 	40 20 10	 100 		I_C = 50 mA, V_{CE} = 1.0 V I_C = 500 mA, V_{CE} = 1.0 V I_C = 1.0 A, V_{CE} = 1.0 V
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage (Note 1)		0.6		0.6		0.6	V	I_C = 1.0 A, I_B = 0.1 A
$V_{BE(sat)}$	Base-Emitter Saturation Voltage (Note 1)		1.3		1.3		1.3	V	I_C = 1.0 A, I_B = 0.1 A
$V_{BE(on)}$	Base-Emitter "On" Voltage (Note 1)		1.3		1.3		1.3	V	I_C = 1.0 A, V_{CE} = 1.0 V
DYNAMIC CHARACTERISTICS									
C_{ob}	Output Capacitance		100		100		100	pF	V_{CB} = 10 V, I_E = 0, f = 0.1 MHz
h_{fe}	Small Signal Current Gain	25		25		25			I_C = 250 mA, V_{CE} = 10 V, f = 1.0 kHz

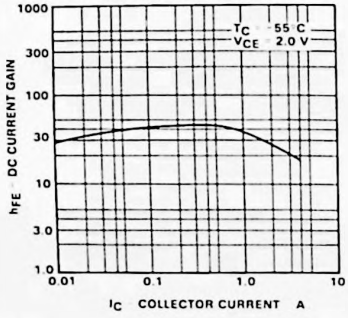
NOTE: 1. Pulse conditions: Length = 300 μs, Duty Cycle = 2%.

TYPICAL ELECTRICAL CHARACTERISTICS

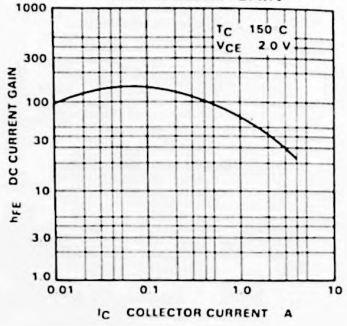
DC CURRENT GAIN



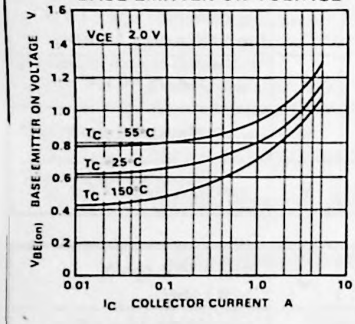
DC CURRENT GAIN



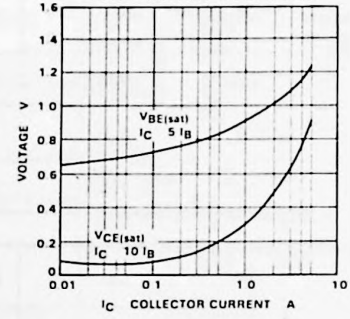
DC CURRENT GAIN



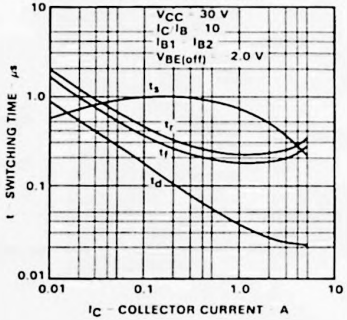
BASE-EMITTER ON VOLTAGE



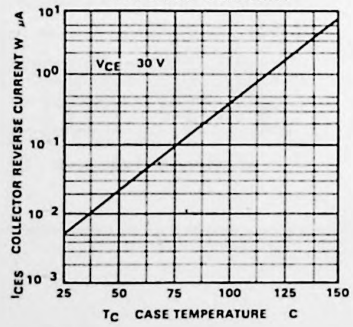
SATURATION VOLTAGES



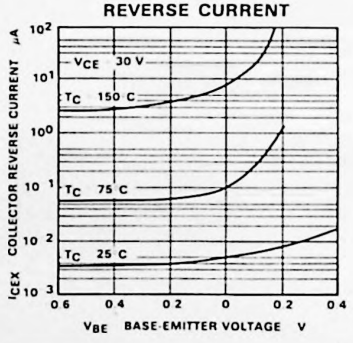
SWITCHING TIMES



COLLECTOR REVERSE CURRENT



COLLECTOR REVERSE CURRENT



POWER TRANSISTOR

NPN SILICON

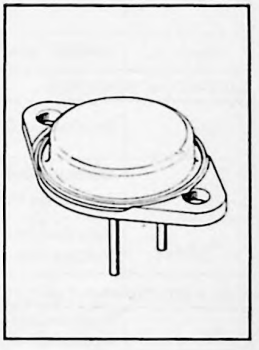
2N4913
2N4914
2N4915

DESIGNED FOR USE IN POWER AMPLIFIER AND SWITCHING CIRCUITS

- 87.5 W DISSIPATION AT 25°C CAST
- 5.0 A MAXIMUM CONTINUOUS COLLECTOR CURRENT
- COMPLEMENTS TO 2N4904, 2N4905, 2N4906

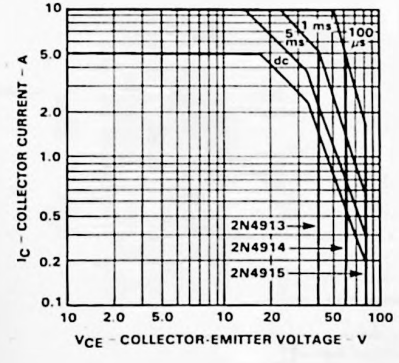
ABSOLUTE MAXIMUM RATINGS (Note 1)

		2N4913	2N4914	2N4915
Maximum Voltages and Currents				
V_{CEO}	Collector to Emitter Voltage	40 V	60 V	80 V
V_{CBO}	Collector to Base Voltage	40 V	60 V	80 V
V_{EBO}	Emitter to Base Voltage	5.0 V	5.0 V	5.0 V
I_C	Continuous Collector Current	5.0 A	5.0 A	5.0 A
I_B	Continuous Base Current	1.0 A	1.0 A	1.0 A
Maximum Power Dissipation				
P_D	Total Dissipation @ 25°C Case Temperature			87.5 W
	Derate Linearly from 25°C			0.5 W/°C
Maximum Temperatures				
T_J, T_{stg}	Storage and Operation Junction Temperatures			−65°C to +200°C
Thermal Characteristics				
$R_{\theta JC}$	Thermal Resistance, Junction to Case			2.0°C/W

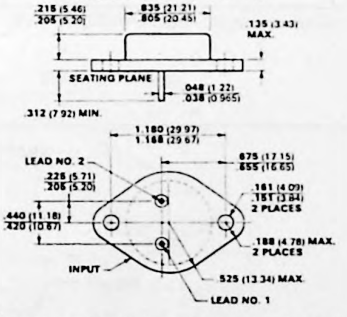


6

SAFE OPERATING AREA



JEDEC (TO-3) Outline



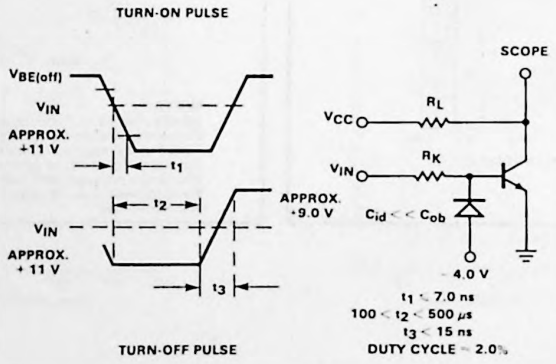
NOTES:
All dimensions in inches (bold) and millimeters (parentheses)
Pins are gold-plated or solder-dipped alloy 52
Pins 1 and 2 electrically isolated from case
Case is third electrical connection
Aluminum package with copper slug, pins are soldered in
Package weight is 7.4 grams
Aluminum cap

ELECTRICAL CHARACTERISTICS (25°C Case Temperature unless otherwise noted)

SYMBOL	CHARACTERISTIC	2N4913		2N4914		2N4915		UNIT	TEST CONDITIONS
		MIN	MAX	MIN	MAX	MIN	MAX		
OFF CHARACTERISTICS									
$V_{CEO(sus)}$	Collector-Emitter Sustaining Voltage (Note 1)	40		60		80		V	I_C = 200 mA, I_B = 0
I_{CEO}	Collector Cutoff Current		1.0					mA	V_{CE} = 40 V, I_B = 0
					1.0			mA	V_{CE} = 60 V, I_B = 0
							1.0	mA	V_{CE} = 80 V, I_B = 0
I_{CEX}	Collector Cutoff Current		1.0					mA	V_{CE} = 40 V
					1.0			mA	V_{CE} = 60 V
							1.0	mA	V_{CE} = 80 V
			2.0					mA	V_{CE} = 40 V, V_{BE} = −1.5 V, T_C = 150°C
					2.0			mA	V_{CE} = 60 V, V_{BE} = −1.5 V, T_C = 150°C
							2.0	mA	V_{CE} = 80 V, V_{BE} = −1.5 V, T_C = 150°C
I_{CBO}	Collector Cutoff Current		1.0					mA	V_{CB} = 40 V, I_E = 0
					1.0			mA	V_{CB} = 60 V, I_E = 0
							1.0	mA	V_{CB} = 80 V, I_E = 0
I_{EBO}	Emitter Cutoff Current		1.0		1.0		1.0	mA	V_{EB} = 5.0 V, I_C = 0
ON CHARACTERISTICS									
h_{FE}	DC Current Gain (Note 1)	25	100	25	100	25	100		I_C = 2.5 A, V_{CE} = 2.0 V
		7.0		7.0		7.0			I_C = 5.0 A, V_{CE} = 2.0 V
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage (Note 1)		1.0		1.0		1.0	V	I_C = 2.5 A, I_B = 0.25 A
			1.5		1.5		1.5	V	I_C = 5.0 A, I_B = 1.0 A
$V_{BE(on)}$	Base-Emitter "On" Voltage (Note 1)		1.4		1.4		1.4	V	I_C = 2.5 A, V_{CE} = 2.0 V
DYNAMIC CHARACTERISTICS									
f_T	Current-Gain-Bandwidth Product	4.0		4.0		4.0		MHz	I_C = 1.0 A, V_{CE} = 10 V, f = 1.0 MHz
h_{fe}	Small Signal Current Gain	20		20		20			I_C = 0.5 A, V_{CE} = 10 V, f = 1.0 kHz

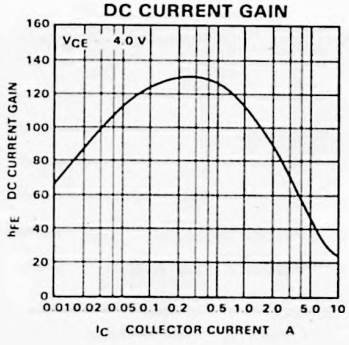
NOTE 1. Pulse conditions: Length = 300 μs, Duty Cycle = 2%.

SWITCHING TIME EQUIVALENT CIRCUIT

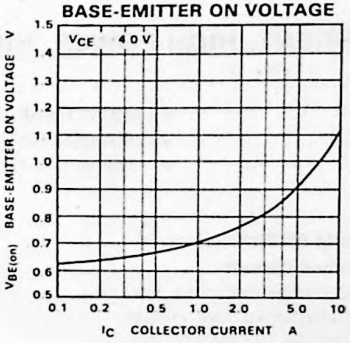


TYPICAL ELECTRICAL CHARACTERISTICS

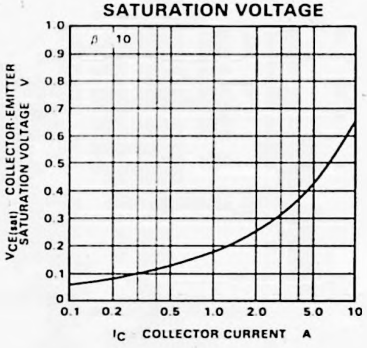
DC CURRENT GAIN



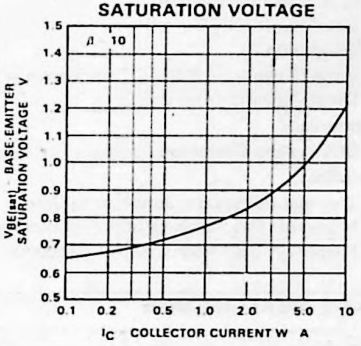
BASE-EMITTER ON VOLTAGE



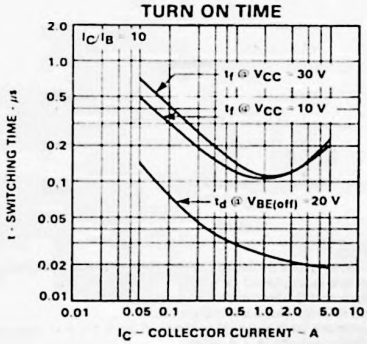
COLLECTOR-EMITTER SATURATION VOLTAGE



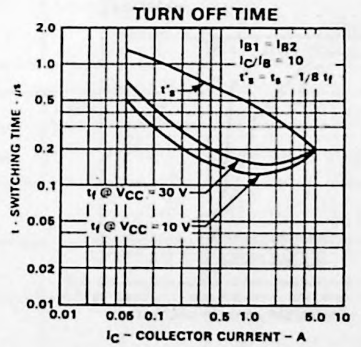
BASE-EMITTER SATURATION VOLTAGE



TURN ON TIME



TURN OFF TIME



POWER TRANSISTOR

NPN SILICON

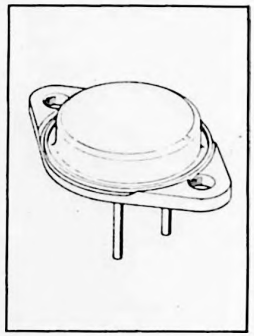
2N5038
2N5039

HIGH CURRENT, HIGH POWER, HIGH SPEED SILICON POWER TRANSISTORS

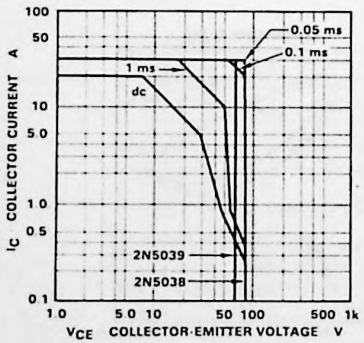
- 140 W DISSIPATION AT 25°C CASE
- 20 A CONTINUOUS COLLECTOR CURRENT
- <1.5 μs t_s @ 12 A (2N5038)

ABSOLUTE MAXIMUM RATINGS (Note 1)

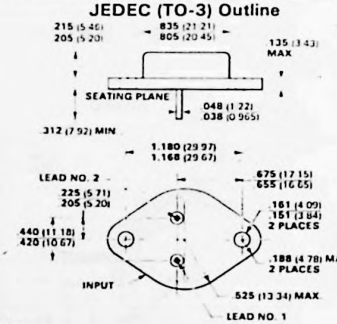
		2N5038	2N5039
Maximum Voltages and Currents			
V_{CEO}	Collector to Emitter Voltage	90 V	75 V
V_{CBO}	Collector to Base Voltage	150 V	120 V
V_{EBO}	Emitter to Base Voltage	7.0 V	7.0 V
I_C	Continuous Collector Current	20 A	20 A
I_C	Peak Collector Current	30 A	30 A
I_B	Continuous Base Current	5.0 A	5.0 A
Maximum Power Dissipation			
P_D	Total Dissipation @ 25°C Case Temperature		140 W
	Derate linearly from 25°C		0.8 W/°C
Maximum Temperatures			
T_J, T_{stg}	Storage and Operation Junction Temperatures		−65°C to 200°C
Thermal Characteristics			
$R_{\theta JC}$	Thermal Resistance, Junction to Case		12.5°C/W
T_P	Maximum Pin Temperatures for Soldering Purposes: 1/8" from Case for 5 seconds		



SAFE OPERATING AREA



JEDEC (TO-3) Outline



NOTES:
All dimensions in inches (bold) and millimeters (parentheses)
Pins are gold-plated or solder-dipped alloy 52
Pins 1 and 2 electrically isolated from case
Case is third electrical connection
Aluminum package with copper slug, pins are soldered in
Package weight is 7.4 grams
Aluminum cap

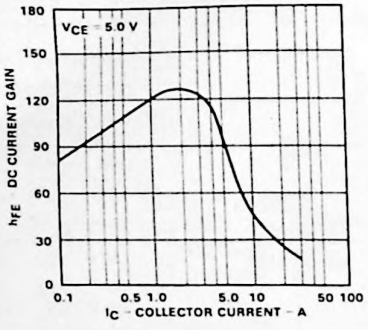
ELECTRICAL CHARACTERISTICS (25°C Case Temperature unless otherwise noted)

SYMBOL	CHARACTERISTIC	2N5038 MIN	2N5038 MAX	2N5039 MIN	2N5039 MAX	UNIT	TEST CONDITIONS
OFF CHARACTERISTICS							
$V_{CEO(sus)}$	Collector-Emitter Sustaining Voltage (Note 1)	90		75		V	I_C = 200 mA, I_B = 0
$V_{CER(sus)}$	Collector-Emitter Sustaining Voltage (Note 1)	110		95		V	I_C = 200 mA, R_{BE} = ≤ 50 Ω
$V_{CEX(sus)}$	Collector-Emitter Sustaining Voltage (Note 1)	150		120		V	I_C = 0.2 A, $V_{BE(off)}$ = −1.5 V
V_{EBO}	Emitter-Base Breakdown Voltage	7.0		7.0		V	I_E = 50 mA, I_C = 0
I_{CEO}	Collector Cutoff Current		20			mA	V_{CE} = 70 V, I_B = 0
					20	mA	V_{CE} = 55 V, I_B = 0
I_{CEX}	Collector Cutoff Current		50			mA	V_{CE} = 140 V, V_{BE} = −1.5 V
					50	mA	V_{CE} = 110 V, V_{BE} = −1.5 V
			10			mA	V_{CE} = 100 V, V_{BE} = −1.5 V, T_C = 150°C
					10	mA	V_{CE} = 85 V, V_{BE} = −1.5 V, T_C = 150°C
I_{EBO}	Emitter Cutoff Current		5.0		15	mA	V_{EB} = 5.0 V, I_C = 0
			50		50	mA	V_{EB} = 7.0 V, I_C = 0
ON CHARACTERISTICS							
h_{FE}	DC Current Gain (Note 1)	50	250	30	250		I_C = 2.0 A, V_{CE} = 5.0 V
		20	100				I_C = 10 A, V_{CE} = 5.0 V
				20	100		I_C = 12 A, V_{CE} = 5.0 V
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage (Note 1)				1.0	V	I_C = 10 A, I_B = 1.0 A
			1.0			V	I_C = 12 A, I_B = 1.2 A
			2.5		2.5	V	I_C = 20 A, I_B = 5.0 A
$V_{BE(sat)}$	Base-Emitter Saturation Voltage (Note 1)		3.3		3.3	V	I_C = 20 A, I_B = 5.0 A
$V_{BE(on)}$	Base-Emitter "On" Voltage (Note 1)				1.8	V	I_C = 10 A, V_{CE} = 5.0 V
					1.8	V	I_C = 12 A, V_{CE} = 5.0 V
SECOND BREAKDOWN							
$I_{S/b}$	Second Breakdown Collector Current with base forward biased	5.0		5.0		A	t = 1.0 s (non repetitive), V_{CE} = 28 V
		0.9		0.9		A	V_{CE} = 45 V
$E_{S/b}$	Second Breakdown Energy with base reversed biased	13		13		mJ	I_C = 12 A, $V_{BE(off)}$ = −4.0 V, L = 180 μH, R_B = 20 Ω
DYNAMIC CHARACTERISTICS							
C_{ob}	Output Capacitance		400		400	pF	V_{CB} = 10 V, I_E = 0
h_{fe}	Magnitude of Common Emitter Small Signal Current Gain	12		12			I_C = 2.0 A, V_{CE} = 10 V, f = 5.0 MHz
SWITCHING CHARACTERISTICS RESISTIVE LOAD							
t_r	Rise Time		0.5			μs	V_{CC} = 30 V, I_C = 12 A, I_{B1} = 1.2 A
					0.5	μs	V_{CC} = 30 V, I_C = 10 A, I_{B1} = 1.0 A
t_s	Storage Time		1.5			μs	V_{CC} = 30 V, I_C = 12 A, I_{B1} = I_{B2} = 1.2 A
					1.5	μs	V_{CC} = 30 V, I_C = 10 A, I_{B1} = I_{B2} = 1.0 A
t_f	Fall Time		0.5			μs	V_{CC} = 30 V, I_C = 12 A, I_{B1} = I_{B2} = 1.2 A
					0.5	μs	V_{CC} = 30 V, I_C = 10 A I_{B1} = I_{B2} = 1.0 A

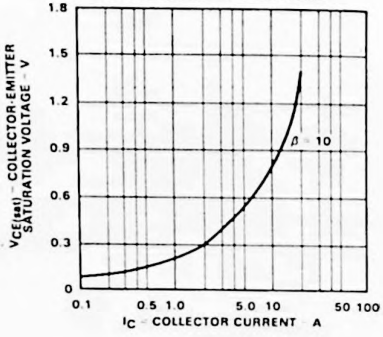
NOTE: 1. Pulse conditions: Length = 300 μs, Duty Cycle = 2%.

TYPICAL ELECTRICAL CHARACTERISTICS

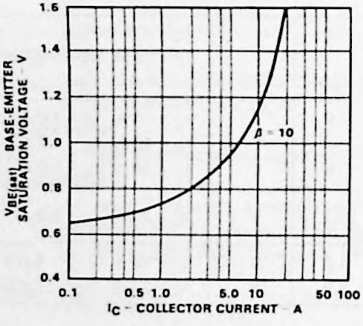
DC CURRENT GAIN



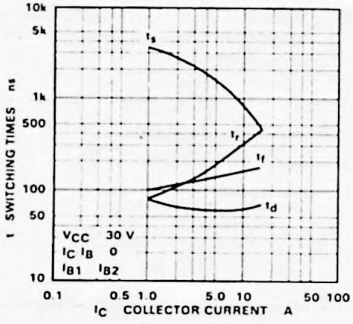
COLLECTOR-EMITTER SATURATION VOLTAGE



BASE-EMITTER SATURATION VOLTAGE



SWITCHING TIME



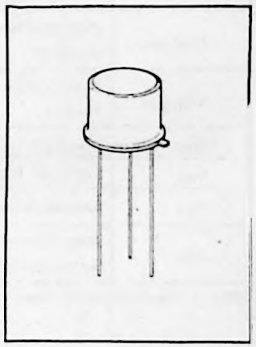
POWER TRANSISTOR

NPN SILICON

2N5058
2N5059

POWER DEVICES DESIGNED PRIMARILY FOR LARGE SIGNAL, LOW POWER, AUDIO FREQUENCY AMPLIFIER APPLICATIONS

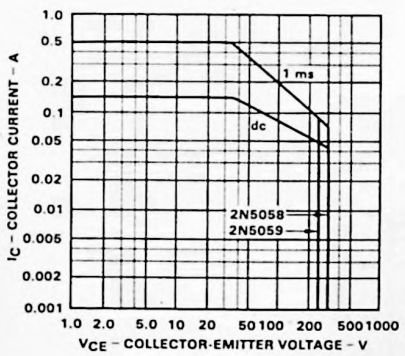
- 5.0 W DISSIPATION AT 25°C CASE
- 150 mA MAXIMUM CONTINUOUS COLLECTOR CURRENT
- HIGH VOLTAGE – V_{CEO} 250 V MIN (2N5059), 300 V MIN (2N5058)



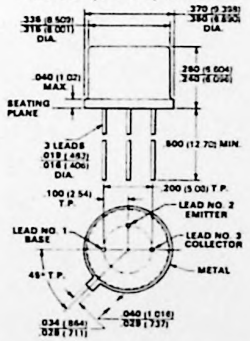
ABSOLUTE MAXIMUM RATINGS (Note 1)

		2N5058	2N5059
Maximum Voltages and Currents			
V_{CEO}	Collector to Emitter Voltage	300 V	250 V
V_{CBO}	Collector to Base Voltage	300 V	250 V
V_{EBO}	Emitter to Base Voltage	7.0 V	7.0 V
I_C	Continuous Collector Current	150 mA	150 mA
Maximum Power Dissipation			
P_D	Total Dissipation @ 25°C Case Temperature		5.0 W
	Derate linearly from 25°C		28.6 mW/°C
Maximum Temperatures			
T_J, T_{stg}	Storage and Operation Junction Temperatures		−65°C to +200°C
Thermal Characteristics			
$R_{\theta JC}$	Thermal Resistance, Junction to Case		35°C/W

SAFE OPERATING AREA



JEDEC (TO-39) Outline



NOTES:
All dimensions in inches (bold) and millimeters (parentheses)
Leads are gold-plated kovar
Lead No. 3 connected to case
Package weight is 0.76 gram

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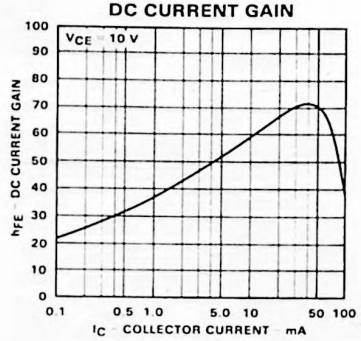
ELECTRICAL CHARACTERISTICS (25°C Case Temperature unless otherwise noted)

SYMBOL	CHARACTERISTIC	2N5058		2N5059		UNIT	TEST CONDITIONS
		MIN	MAX	MIN	MAX		
OFF CHARACTERISTICS							
$V_{CEO(sus)}$	Collector-Emitter Sustaining Voltage (Note 1)	300		250		V	I_C = 30 mA, I_B = 0
V_{CBO}	Collector-Base Breakdown Voltage	300		225		V	I_C = 0.1 mA, I_E = 0
V_{EBO}	Emitter-Base Breakdown Voltage	7.0		6.0		V	I_E = 0.1 mA, I_C = 0
I_{CBO}	Collector Cutoff Current		0.05 0.02		0.05 0.02	μA mA	V_{CB} = 100 V, I_E = 0 V_{CB} = 100 V, I_E = 0, T_C = 125°C
I_{EBO}	Emitter Cutoff Current		0.01		0.01	mA	V_{EB} = 5.0 V, I_C = 0
ON CHARACTERISTICS							
h_{FE}	DC Current Gain (Note 1)	10 35 35 10	150	10 30 30	150		I_C = 5.0 mA, V_{CE} = 25 V I_C = 30 mA, V_{CE} = 25 V I_C = 100 mA, V_{CE} = 25 V I_C = 30 mA, V_{CE} = 25 V, T_C = −55°C
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage (Note 1)		1.0		1.0	V	I_C = 30 mA, I_B = 3.0 mA
$V_{BE(sat)}$	Base-Emitter Saturation Voltage (Note 1)		0.85		0.85	V	I_C = 30 mA, I_B = 3.0 mA
$V_{BE(on)}$	Base-Emitter "On" Voltage (Note 1)		0.82		0.82	V	I_C = 30 mA, V_{CE} = 25 V
DYNAMIC CHARACTERISTICS							
C_{cb}	Collector-Base Capacitance		10		10	pF	V_{CB} = 10 V, I_E = 0, f = 1.0 MHz
C_{eb}	Emitter-Base Capacitance		75		75	pF	V_{EB} = 0.5 V, I_C = 0, f = 1.0 MHz
h_{fe}	Magnitude of Common Emitter Small Signal Current Gain	1.5	8.0	1.5	8.0		I_C = 10 mA, V_{CE} = 25 V, f = 20 MHz

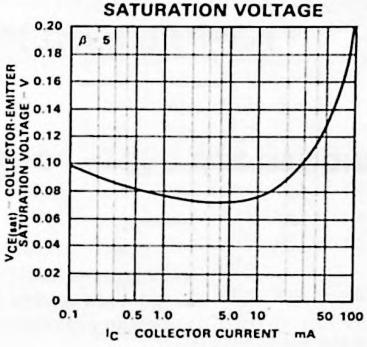
NOTE: 1. Pulse conditions: Length = 300 μs, Duty Cycle = 2%.

TYPICAL ELECTRICAL CHARACTERISTICS

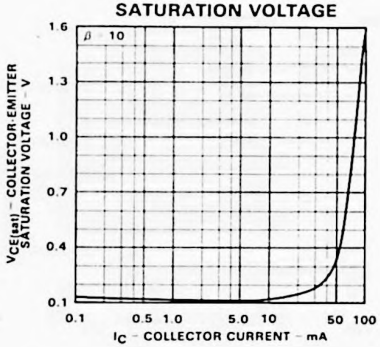
DC CURRENT GAIN



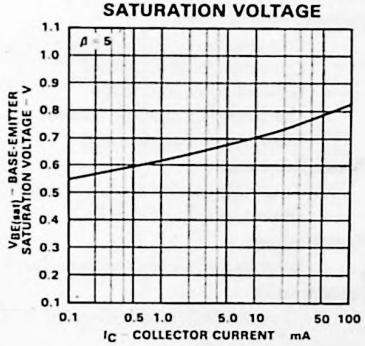
COLLECTOR-EMITTER SATURATION VOLTAGE



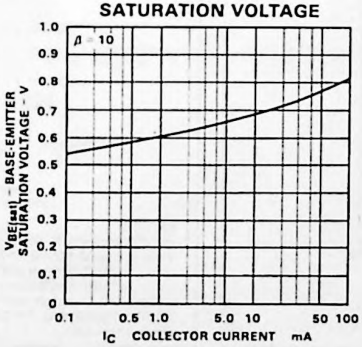
COLLECTOR-EMITTER SATURATION VOLTAGE



BASE-EMITTER SATURATION VOLTAGE



BASE-EMITTER SATURATION VOLTAGE



POWER TRANSISTOR

NPN SILICON

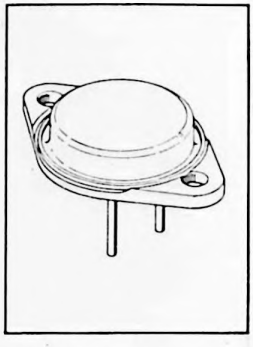
2N5067
2N5068
2N5069

DESIGNED FOR USE IN POWER AMPLIFIER AND SWITCHING CIRCUITS

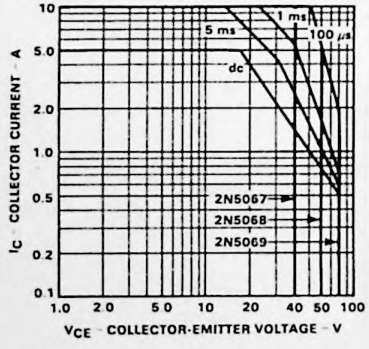
- 87.5 W DISSIPATION AT 25°C CASE
- 5.0 A MAXIMUM CONTINUOUS COLLECTOR CURRENT
- COMPLEMENTS TO 2N4901, 2N4902, 2N4903

ABSOLUTE MAXIMUM RATINGS (Note 1)

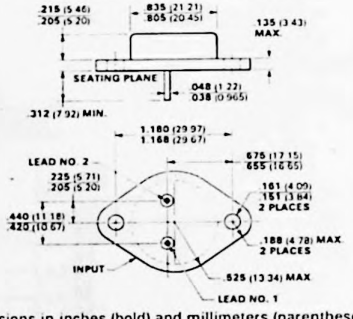
		2N5067	2N5068	2N5069
Maximum Voltages and Currents				
V_{CEO}	Collector to Emitter Voltage	40 V	60 V	80 V
V_{CBO}	Collector to Base Voltage	40 V	60 V	80 V
V_{EBO}	Emitter to Base Voltage	5.0 V	5.0 V	5.0 V
I_C	Continuous Collector Current	5.0 A	5.0 A	5.0 A
I_B	Continuous Base Current	1.0 A	1.0 A	1.0 A
Maximum Power Dissipation				
P_D	Total Dissipation @ 25°C Case Temperature			87.5 W
	Derate Linearly from 25°C			0.5 W/°C
Maximum Temperatures				
T_J, T_{stg}	Storage and Operation Junction Temperatures			−65°C to +200°C
Thermal Characteristics				
$R_{\theta JC}$	Thermal Resistance, Junction to Case			2.0 °C/W



SAFE OPERATING AREA



JEDEC (TO-3) Outline



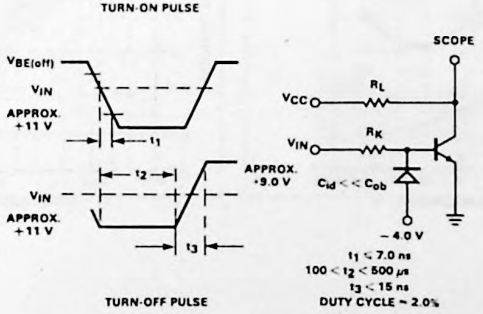
NOTES:
All dimensions in inches (bold) and millimeters (parentheses)
Pins are gold-plated or solder-dipped alloy 52
Pins 1 and 2 electrically isolated from case
Case is third electrical connection
Aluminum package with copper slug, pins are soldered in
Package weight is 7.4 grams
Aluminum cap

ELECTRICAL CHARACTERISTICS (25°C Case Temperature unless otherwise noted)

SYMBOL	CHARACTERISTIC	2N5067		2N5068		2N5069		UNIT	TEST CONDITIONS
		MIN	MAX	MIN	MAX	MIN	MAX		
OFF CHARACTERISTICS									
$V_{CEO(sus)}$	Collector-Emitter Sustaining Voltage (Note 1)	40		60		80		V	I_C = 200 mA, I_B = 0
I_{CEO}	Collector Cutoff Current		1.0					mA	V_{CE} = 40 V, I_B = 0
					1.0			mA	V_{CE} = 60 V, I_B = 0
							1.0	mA	V_{CE} = 80 V, I_B = 0
I_{CEX}	Collector Cutoff Current		1.0					mA	V_{CE} = 40 V, V_{BE} = −1.5 V
					1.0			mA	V_{CE} = 60 V, V_{BE} = −1.5 V
							1.0	mA	V_{CE} = 80 V, V_{BE} = −1.5 V
			2.0					mA	V_{CE} = 40 V, V_{BE} = −1.5 V, T_C = 150°C
					2.0			mA	V_{CE} = 60 V, V_{BE} = −1.5 V, T_C = 150°C
							2.0	mA	V_{CE} = 80 V, V_{BE} = −1.5 V, T_C = 150°C
I_{CBO}	Collector Cutoff Current		1.0					mA	V_{CB} = 40 V, I_E = 0
					1.0			mA	V_{CB} = 60 V, I_E = 0
							1.0	mA	V_{CB} = 80 V, I_E = 0
I_{EBO}	Emitter Cutoff Current		1.0		1.0		1.0	mA	V_{EB} = 5.0 V, I_C = 0
ON CHARACTERISTICS									
h_{FE}	DC Current Gain (Note 1)	20	80	20	80	20	80		I_C = 1.0 A, V_{CE} = 2.0 V
		7.0		7.0		7.0			I_C = 5.0 A, V_{CE} = 2.0 V
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage (Note 1)		0.4		0.4		0.4	V	I_C = 1.0 A, I_B = 0.1 A
			1.5		1.5		1.5	V	I_C = 5.0 A, I_B = 1.0 A
$V_{BE(on)}$	Base-Emitter "On" Voltage (Note 1)		1.2		1.2		1.2	V	I_C = 1.0 A, V_{CE} = 2.0 V
DYNAMIC CHARACTERISTICS									
f_T	Current-Gain-Bandwidth Product	4.0		4.0		4.0		MHz	I_C = 1.0 A, V_{CE} = 10 V, f = 1.0 MHz
h_{fe}	Small Signal Current Gain	20		20		20			I_C = 0.5 A, V_{CE} = 10 V, f = 1.0 kHz

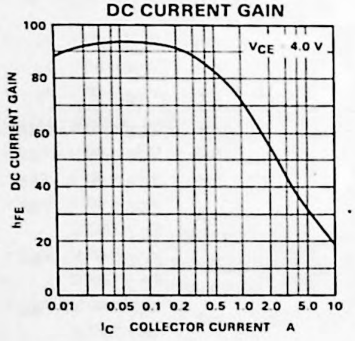
NOTE: 1. Pulse conditions: Length = 300 μs, Duty Cycle = 2%.

SWITCHING TIME EQUIVALENT CIRCUIT

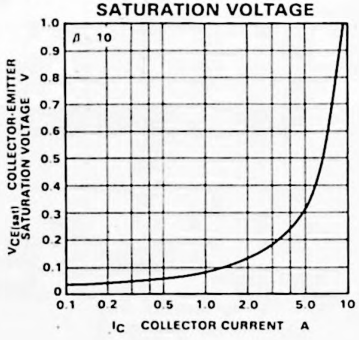


TYPICAL ELECTRICAL CHARACTERISTICS

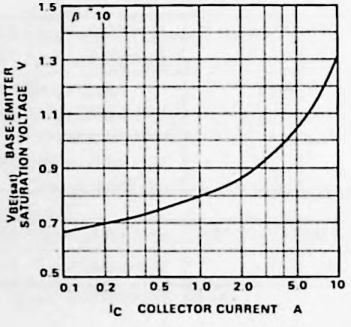
DC CURRENT GAIN



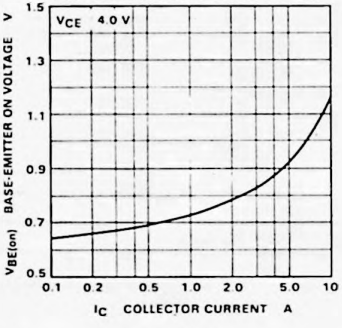
COLLECTOR-EMITTER SATURATION VOLTAGE



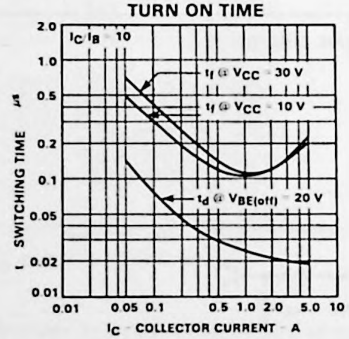
BASE-EMITTER SATURATION VOLTAGE



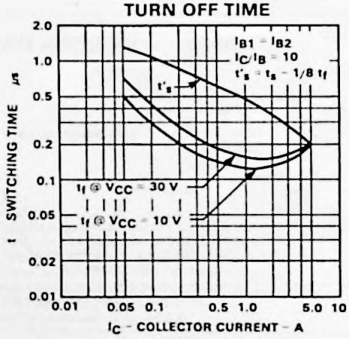
BASE-EMITTER ON VOLTAGE



TURN ON TIME



TURN OFF TIME



POWER TRANSISTOR

NPN SILICON

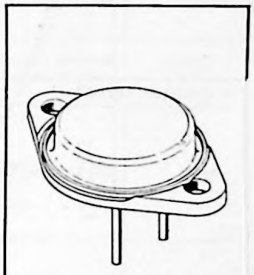
2N5301
2N5302
2N5303

HIGH POWER TRANSISTORS FOR USE IN POWER AMPLIFIER AND SWITCHING CIRCUITS APPLICATIONS

- 200 W DISSIPATION AT 25°C CASE
- 30 A MAXIMUM CONTINUOUS COLLECTOR CURRENT
- COMPLEMENTS 2N4398 (2N5301) 2N4399 (2N5302)

ABSOLUTE MAXIMUM RATINGS (Note 1)

		2N5301	2N5302	2N5303
Maximum Voltages and Currents				
V_{CEO}	Collector to Emitter Voltage	40 V	60 V	80 V
V_{CBO}	Collector to Base Voltage	40 V	60 V	80 V
V_{EBO}	Emitter to Base Voltage	5.0 V	5.0 V	5.0 V
I_C	Continuous Collector Current	30 A	30 A	30 A
I_B	Continuous Base Current	7.5 A	7.5 A	7.5 A
Maximum Power Dissipation				
P_D	Total Dissipation @ 25°C Case Temperature			200 W
	Derate Linearly from 25°C			1.14 W/°C
Maximum Temperatures				
T_J, T_{stg}	Storage and Operation Junction Temperatures			−65°C to +200°C
Thermal Characteristics				
$R_{\theta JC}$	Thermal Resistance, Junction to Case			0.875°C/W



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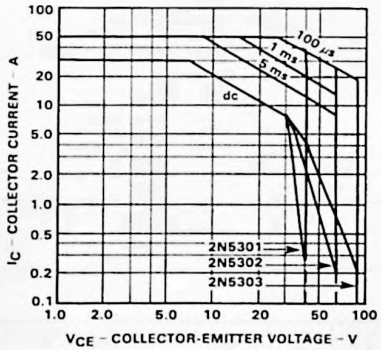
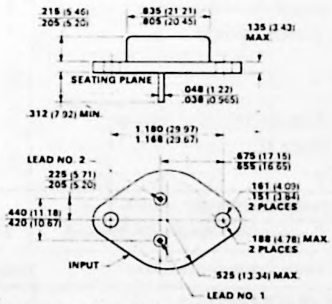
SAFE OPERATING AREA



JEDEC (TO-3) Outline



NOTES:
All dimensions in inches (bold) and millimeters (parentheses)
Pins are gold-plated or solder-dipped alloy 52
Pins 1 and 2 electrically isolated from case
Case is third electrical connection
Aluminum package with copper slug, pins are soldered in
Package weight is 7.4 grams
Aluminum cap

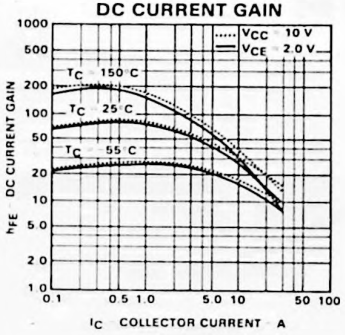
ELECTRICAL CHARACTERISTICS (25°C Case Temperature unless otherwise noted)

SYMBOL	CHARACTERISTIC	2N5301		2N5302		2N5303		UNIT	TEST CONDITIONS
		MIN	MAX	MIN	MAX	MIN	MAX		
OFF CHARACTERISTICS									
$V_{CEO(sus)}$	Collector-Emitter Sustaining Voltage (Note 1)	40		60		80		V	I_C = 200 mA, I_B = 0
I_{CEO}	Collector Cutoff Current		5.0					mA	V_{CE} = 40 V, I_B = 0
					5.0			mA	V_{CE} = 60 V, I_B = 0
							5.0	mA	V_{CE} = 80 V, I_B = 0
I_{CEX}	Collector Cutoff Current		1.0					mA	V_{CE} = 40 V, V_{BE} = −1.5 V
					1.0			mA	V_{CE} = 60 V, V_{BE} = −1.5 V
							1.0	mA	V_{CE} = 80 V, V_{BE} = −1.5 V
			10					mA	V_{CE} = 40 V, V_{BE} = −1.5 V, T_C = 150°C
					10			mA	V_{CE} = 60 V, V_{BE} = −1.5 V, T_C = 150°C
							10	mA	V_{CE} = 80 V, V_{BE} = −1.5 V, T_C = 150°C
I_{CBO}	Collector Cutoff Current		1.0					mA	V_{CB} = 40 V, I_E = 0
					1.0			mA	V_{CB} = 60 V, I_E = 0
							1.0	mA	V_{CB} = 80 V, I_E = 0
I_{EBO}	Emitter Cutoff Current		5.0		5.0		5.0	mA	V_{EB} = 5.0 V, I_C = 0
ON CHARACTERISTICS									
h_{FE}	DC Current Gain (Note 1)	5.0		5.0		5.0			I_C = 30 A, V_{CE} = 3.0 V
									I_C = 20 A, V_{CE} = 2.0 V
		15	60	15	60				I_C = 15 A, V_{CE} = 3.0 V
						15	60		I_C = 10 A, V_{CE} = 2.0 V
		40		40		40			I_C = 1.0 A, V_{CE} = 2.0 V
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage (Note 1)		0.75		0.75		1.0	V	I_C = 10 A, I_B = 1.0 A
							1.5	V	I_C = 15 A, I_B = 1.5 A
			2.0		2.0			V	I_C = 20 A, I_B = 2.0 A
							2.0	V	I_C = 20 A, I_B = 4.0 A
			3.0		3.0			V	I_C = 30 A, I_B = 6.0 A
$V_{BE(sat)}$	Base-Emitter Saturation Voltage (Note 1)		1.7		1.7		1.7	V	I_C = 10 A, I_B = 1.0 A
			1.8		1.8		2.0	V	I_C = 15 A, I_B = 1.5 A
			2.5		2.5			V	I_C = 20 A, I_B = 2.0 A
							2.5	V	I_C = 20 A, I_B = 4.0 A
$V_{BE(on)}$	Base-Emitter "On" Voltage (Note 1)		1.8		1.8			V	I_C = 15 A, V_{CE} = 2.0 V
							1.5	V	I_C = 10 A, V_{CE} = 2.0 V
			3.0		3.0			V	I_C = 30 A, V_{CE} = 4.0 V
							2.5	V	I_C = 20 A, V_{CE} = 4.0 V
DYNAMIC CHARACTERISTICS									
f_T	Current-Gain-Bandwidth Product	2.0		2.0		2.0		MHz	I_C = 1.0 A, V_{CE} = 10 V, f = 1.0 MHz
h_{fe}	Small Signal Current Gain	40		40		40			I_C = 1.0 A, V_{CE} = 10 V, f = 1.0 kHz
SWITCHING CHARACTERISTICS									
RESISTIVE LOAD									
t_r	Rise Time		1.0		1.0		1.0	μs	V_{CC} = 30 V, I_C = 10 A, I_{B1} = 1.0 A, t_p = 10-100 μs, Duty Cycle = 2.0 %
t_s	Storage Time		2.0		2.0		2.0	μs	V_{CC} = 30 V, I_C = 10 A, I_{B1} = I_{B2} = 1.0 A, t_p = 10-100 μs Duty Cycle = 2.0%
t_f	Fall Time		1.0		1.0		1.0	μs	

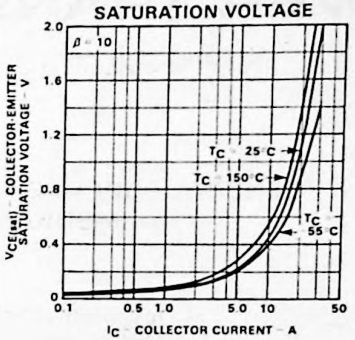
NOTE: 1. Pulse conditions: Length = 300 μs, Duty Cycle = 2%.

TYPICAL ELECTRICAL CHARACTERISTICS

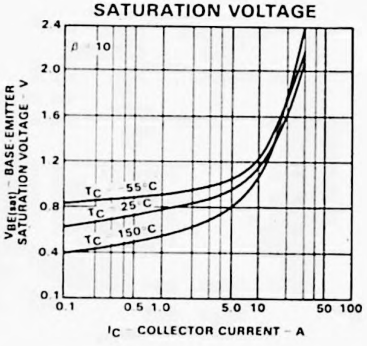
DC CURRENT GAIN



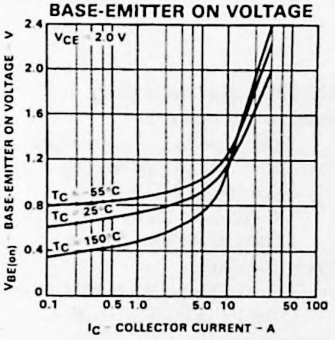
COLLECTOR-EMITTER SATURATION VOLTAGE



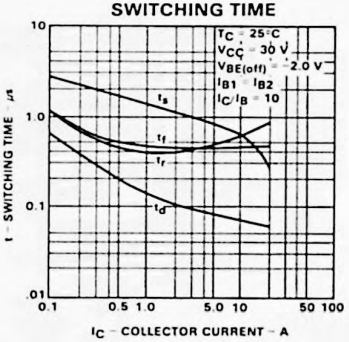
BASE-EMITTER SATURATION VOLTAGE



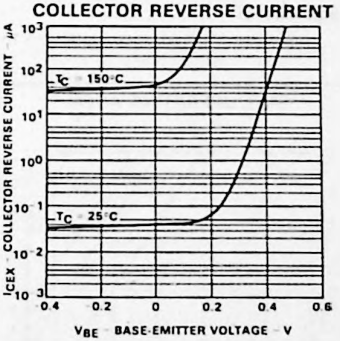
BASE-EMITTER ON VOLTAGE



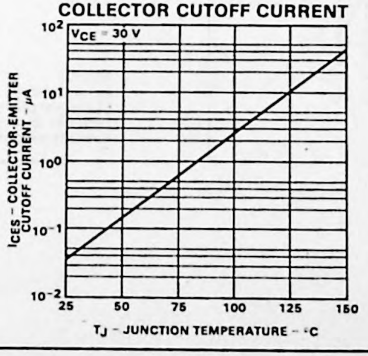
SWITCHING TIME



COLLECTOR REVERSE CURRENT



COLLECTOR CUTOFF CURRENT



POWER TRANSISTOR

NPN SILICON

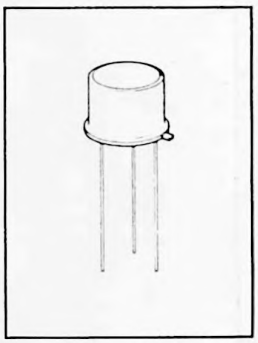
2N5320
2N5321

GENERAL PURPOSE POWER DEVICES FOR SMALL SIGNAL, MEDIUM POWER APPLICATIONS

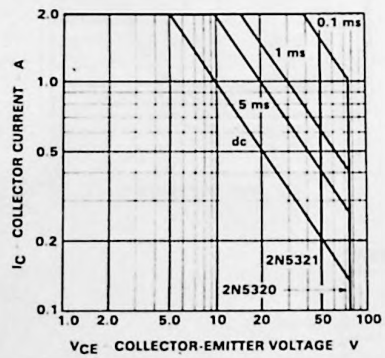
- 10 W DISSIPATION AT 25°C CASE
- 2.0 A MAXIMUM CONTINUOUS COLLECTOR CURRENT
- COMPLEMENTS 2N5322, 2N5323

ABSOLUTE MAXIMUM RATINGS (Note 1)

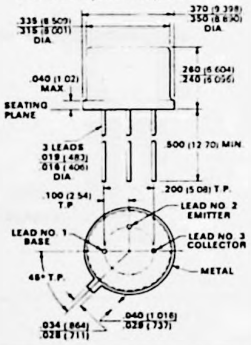
		2N5320	2N5321
Maximum Voltages and Currents			
V_{CEO}	Collector to Emitter Voltage	75 V	50 V
V_{CBO}	Collector to Base Voltage	100 V	75 V
V_{EBO}	Emitter to Base Voltage	7.0 V	7.0 V
I_C	Continuous Collector Current	2.0 A	2.0 A
I_B	Continuous Base Current	1.0 A	1.0 A
Maximum Power Dissipation			
P_D	Total Dissipation @ 25°C Case Temperature		10 W
	Derate Linearly from 25°C		0.057 W/°C
Maximum Temperatures			
T_J, T_{stg}	Storage and Operation Junction Temperatures		−65°C to +200°C
Thermal Characteristics			
$R_{\theta JC}$	Thermal Resistance, Junction to Case		17.5°C/W



SAFE OPERATING AREA



JEDEC (TO-39) outline



NOTES:
All dimensions in inches (bold) and millimeters (parentheses)
Leads are gold-plated kovar
Lead No. 3 connected to case
Package weight is 0.76 gram

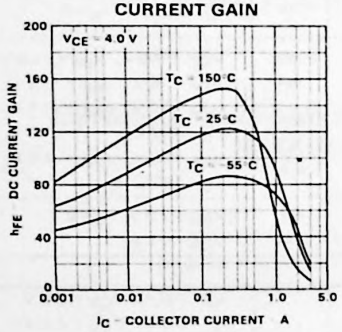
ELECTRICAL CHARACTERISTICS (25°C Case Temperature unless otherwise noted)

SYMBOL	CHARACTERISTIC	2N5320		2N5321		UNIT	TEST CONDITIONS
		MIN	MAX	MIN	MAX		
OFF CHARACTERISTICS							
$V_{CEO(sus)}$	Collector-Emitter Sustaining Voltage (Note 1)	75		50		V	I_C = 100 mA, I_B = 0
I_{CEX}	Collector Cutoff Current		0.1		0.1	mA	V_{CE} = 100 V, V_{BE} = −1.5 V
						mA	V_{CE} = 75 V, V_{BE} = −1.5 V
			5.0			mA	V_{CE} = 70 V, V_{BE} = −1.5 V, T_C = 150°C
					5.0	mA	V_{CE} = 45 V, V_{BE} = −1.5 V, T_C = 150°C
I_{EBO}	Emitter Cutoff Current		0.1			mA	V_{EB} = 7.0 V, I_C = 0
					0.1	mA	V_{EB} = 5.0 V
ON CHARACTERISTICS							
h_{FE}	DC Current Gain (Note 1)	10		10			I_C = 1.0 A, V_{CE} = 2.0 V
		30	130	40	250		I_C = 0.5 A, V_{CE} = 4.0 V
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage (Note 1)		0.5		0.8	V	I_C = 0.5 A, I_B = 0.05 A
$V_{BE(on)}$	Base-Emitter "On" Voltage (Note 1)		1.1		1.4	V	I_C = 0.5 A, V_{CE} = 4.0 V
DYNAMIC CHARACTERISTICS							
f_T	Current-Gain-Bandwidth Product	5.0		5.0		MHz	I_C = 0.05 A, V_{CE} = 4.0 V, f = 10 MHz
SWITCHING CHARACTERISTICS							
t_{on}	Turn On Time		80		80	μs	I_C = 500 mA, V_{CC} = 30 V, I_{B1} = 50 mA
t_{off}	Turn Off Time		800		800	μs	I_C = 500 mA, V_{CC} = 30 V, I_{B1} = I_{B2} = 50 mA

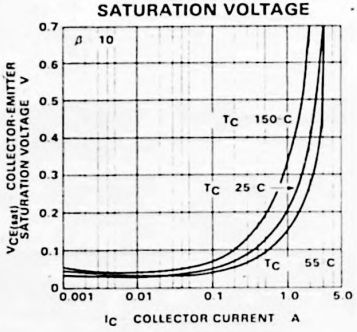
NOTE: 1. Pulse conditions: Length = 300 μs, Duty Cycle = 2%.

TYPICAL ELECTRICAL CHARACTERISTICS

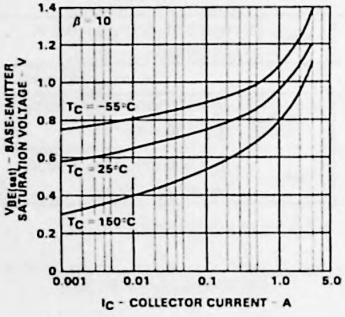
CURRENT GAIN



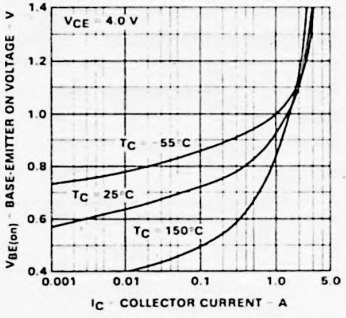
COLLECTOR-EMITTER SATURATION VOLTAGE



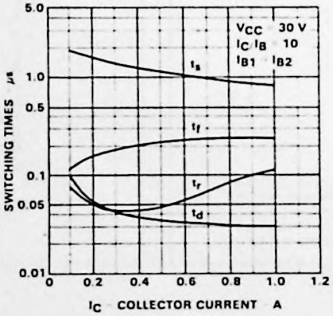
BASE-EMITTER SATURATION VOLTAGE



BASE-EMITTER ON VOLTAGE



SWITCHING TIMES



POWER TRANSISTOR

PNP SILICON

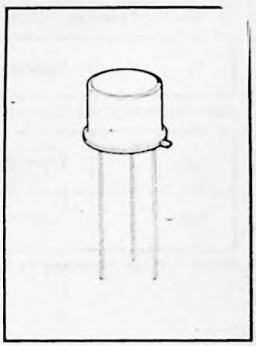
2N5322
2N5323

GENERAL PURPOSE POWER DEVICES FOR SMALL SIGNAL, MEDIUM POWER APPLICATIONS

- 10 W DISSIPATION AT 25°C CASE
- 2.0 A MAXIMUM CONTINUOUS COLLECTOR CURRENT
- COMPLEMENT 2N5320, 2N5321

ABSOLUTE MAXIMUM RATINGS (Note 1)

		2N5322	2N5323
Maximum Voltages and Currents			
V_{CEO}	Collector to Emitter Voltage	−75 V	−50 V
V_{CBO}	Collector to Base Voltage	−100 V	−75 V
V_{EBO}	Emitter to Base Voltage	−7.0 V	−7.0 V
I_C	Continuous Collector Current	−2.0 A	2.0 A
I_B	Continuous Base Current	1.0 A	1.0 A
Maximum Power Dissipation			
P_D	Total Dissipation @ 25°C Case Temperature		10 W
	Derate Linearly from 25°C		0.057 W/°C
Maximum Temperatures			
T_J, T_{stg}	Storage and Operation Junction Temperatures		−65°C to +200°C
Thermal Characteristics			
$R_{\theta JC}$	Thermal Resistance, Junction to Case		17.5°C/W



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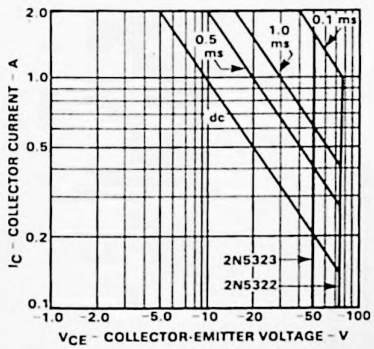
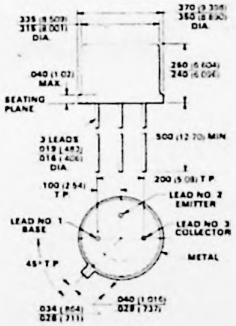
SAFE OPERATING AREA



JEDEC (TO-39) Outline



NOTES:
All dimensions in inches (bold) and millimeters (parentheses)
Leads are gold-plated kovar
Lead No. 3 connected to case
Package weight is 0.76 gram

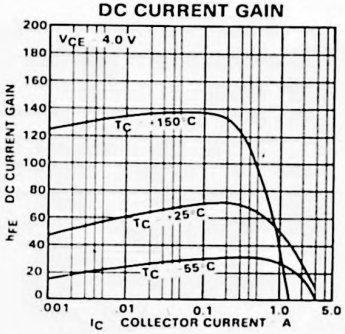
ELECTRICAL CHARACTERISTICS (25°C Case Temperature unless otherwise noted)

SYMBOL	CHARACTERISTIC	2N5322		2N5323		UNIT	TEST CONDITIONS
		MIN	MAX	MIN	MAX		
OFF CHARACTERISTICS							
$V_{CEO(sus)}$	Collector-Emitter Sustaining Voltage (Note 1)	−75		−50		V	I_C = 0.1 mA, I_B = 0
I_{CEX}	Collector Cutoff Current		0.1			mA	V_{CE} = −100 V, V_{BE} = 1.5 V
					0.1	mA	V_{CE} = −75 V, V_{BE} = 1.5 V
			5.0			mA	V_{CE} = −70 V, V_{BE} = 1.5 V, T_C = 150°C
					5.0	mA	V_{CE} = −45 V, V_{BE} = 1.5 V, T_C = 150°C
I_{EBO}	Emitter Cutoff Current		0.1			mA	V_{EB} = −7.0 V, I_C = 0
					0.1	mA	V_{EB} = −5.0 V, I_C = 0
ON CHARACTERISTICS							
h_{FE}	DC Current Gain (Note 1)	10		10			I_C = 1.0 A, V_{CE} = −2.0 V
		30	130	40	250		I_C = 0.5 A, V_{CE} = −4.0 V
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage (Note 1)		−0.7		−1.2	V	I_C = 0.5 A, I_B = 0.05 A
$V_{BE(on)}$	Base-Emitter "On" Voltage (Note 1)		−1.1		−1.4	V	I_C = 0.5 A, V_{CE} = −4.0 V
DYNAMIC CHARACTERISTICS							
f_T	Current-Gain-Bandwidth Product	5.0		5.0		MHz	I_C = 0.05 A, V_{CE} = −4.0 V, f = 10 MHz
SWITCHING CHARACTERISTICS							
t_{on}	Turn On Time		100		100	μs	I_C = 500 mA, V_{CC} = −30 V, I_{B1} = 50 mA
t_{off}	Turn Off Time		1000		1000	μs	I_C = 500 mA, V_{CC} = −30 V, I_{B1} = I_{B2} = 50 mA

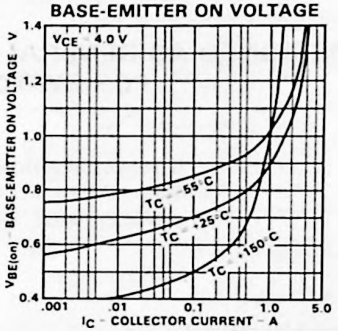
NOTE: 1. Pulse conditions: Length = 300 μs, Duty Cycle = 2%.

TYPICAL ELECTRICAL CHARACTERISTICS

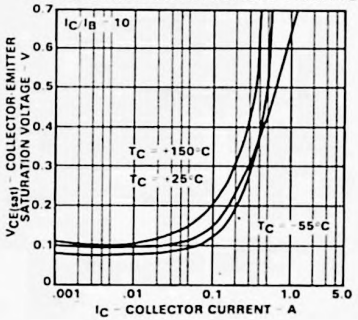
DC CURRENT GAIN



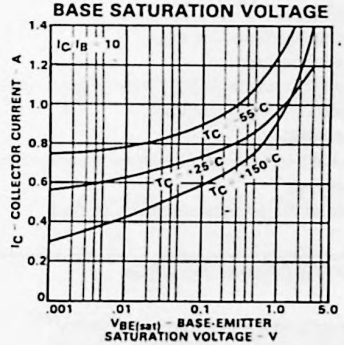
BASE-EMITTER ON VOLTAGE



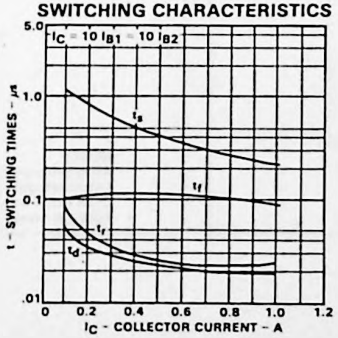
COLLECTOR-SATURATION VOLTAGE



BASE SATURATION VOLTAGE



SWITCHING CHARACTERISTICS



POWER TRANSISTOR

NPN SILICON

2N5334
2N5335

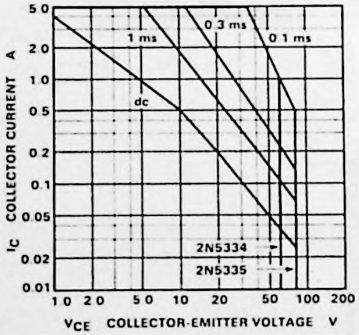
DESIGNED AS GENERAL PURPOSE MEDIUM POWER DEVICE FOR SWITCHING APPLICATIONS

- 6.0 W DISSIPATION AT 25°C CASE
- 3.0 A MAXIMUM CONTINUOUS COLLECTOR CURRENT
- LOW LEAKAGE, $I_{CES(MAX)}$ 100 μA @ T_C = 150°C

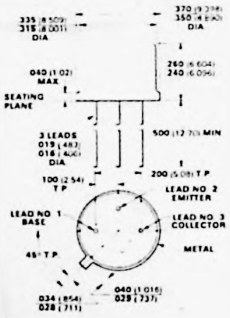
ABSOLUTE MAXIMUM RATINGS (Note 1)

		2N5334	2N5335
Maximum Voltages and Currents			
V_{CEO}	Collector to Emitter Voltage	60 V	80 V
V_{CBO}	Collector to Base Voltage	60 V	80 V
V_{EBO}	Emitter to Base Voltage	8.0 V	8.0 V
I_C	Continuous Collector Current	3.0 A	3.0 A
I_B	Continuous Base Current	1.0 A	1.0 A
Maximum Power Dissipation			
P_D	Total Dissipation @ 25°C Case Temperature		6.0 W
	Derate Linearly from 25°C		34 mW/°C
Maximum Temperatures			
T_J, T_{stg}	Storage and Operation Junction Temperatures		−65°C to +200°C
Thermal Characteristics			
$R_{\theta JC}$	Thermal Resistance, Junction to Case		29.1°C/W

SAFE OPERATING AREA



JEDEC (TO-39) Outline



NOTES:
All dimensions in inches (bold) and millimeters (parentheses)
Leads are gold-plated kovar
Lead No. 3 connected to case
Package weight is 1.23 grams

ELECTRICAL CHARACTERISTICS (25°C Case Temperature unless otherwise noted)

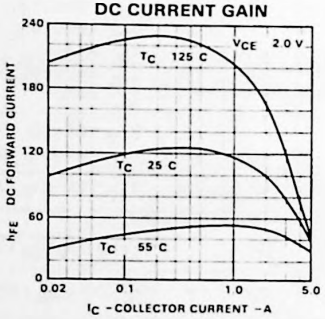
SYMBOL	CHARACTERISTIC	2N5334		2N5335		UNIT	TEST CONDITIONS
		MIN	MAX	MIN	MAX		
OFF CHARACTERISTICS							
$V_{CEO(sus)}$	Collector-Emitter Sustaining Voltage (Note 1)	60		80		V	$I_C = 50$ mA, $I_B = 0$
I_{CEX}	Collector Cutoff Current		5.0			μA	$V_{CE} = 55$ V, $V_{BE} = -1.5$ V
					5.0	μA	$V_{CE} = 75$ V, $V_{BE} = -1.5$ V
			0.5			mA	$V_{CE} = 55$ V, $V_{BE} = -1.5$ V, $T_C = 150°C$
					0.5	mA	$V_{CE} = 75$ V, $V_{BE} = -1.5$ V, $T_C = 150°C$
I_{CBO}	Collector Cutoff Current		5.0			μA	$V_{CB} = 60$ V, $I_E = 0$
					5.0	μA	$V_{CB} = 80$ V, $I_E = 0$
I_{EBO}	Emitter Cutoff Current		0.1		0.1	mA	$V_{EB} = 8.0$ V, $I_C = 0$
ON CHARACTERISTICS							
h_{FE}	DC Current Gain (Note 1)	30	150	30	150		$I_C = 1.0$ A, $V_{CE} = 2.0$ V
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage (Note 1)		0.7		0.7	V	$I_C = 2.0$ A, $I_B = 0.2$ A
$V_{BE(sat)}$	Base-Emitter Saturation Voltage (Note 1)		1.5		1.5	V	$I_C = 2.0$ A, $I_B = 0.2$ A
DYNAMIC CHARACTERISTICS							
C_{ib}	Input Capacitance		250		250	pF	$V_{EB} = 2.0$ V, $I_C = 0$, f = 0.1 MHz
C_{ob}	Output Capacitance		75		75	pF	$V_{CB} = 10$ V, $I_E = 0$, f = 0.1 MHz
h_{fe}	Magnitude of Common Emitter Small Signal Current Gain	4.0		4.0			$I_C = 100$ mA, $V_{CE} = 10$ V, f = 10 MHz
SWITCHING CHARACTERISTICS							
RESISTIVE LOAD							
t_r	Rise Time		50		50	μs	$V_{CC} = 20$ V, $I_C = 1.0$ A, $I_{B1} = 100$ mA, $t_p = 10$ μs, Duty Cycle 1 kHz
t_s	Storage Time		950		950	μs	$V_{CC} = 20$ V, $I_C = 1.0$ A, $I_{B1} = I_{B2} = 100$ mA, $t_p = 10$ μs, Duty Cycle 1 kHz
t_f	Fall Time		100		100	μs	

NOTE: 1. Pulse conditions: Length = 300 μs, Duty Cycle = 2%.

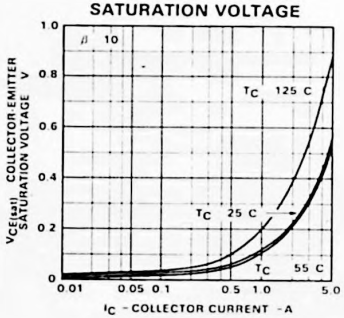
6

TYPICAL ELECTRICAL CHARACTERISTICS

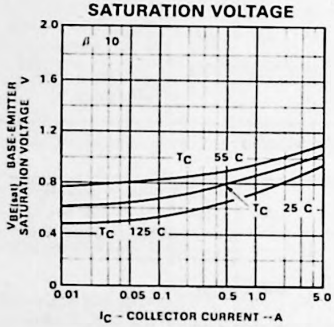
DC CURRENT GAIN



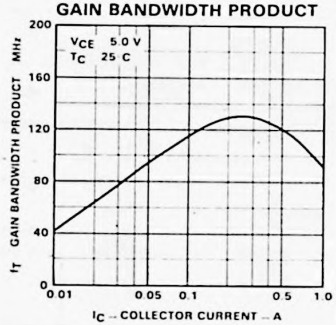
COLLECTOR-EMITTER SATURATION VOLTAGE



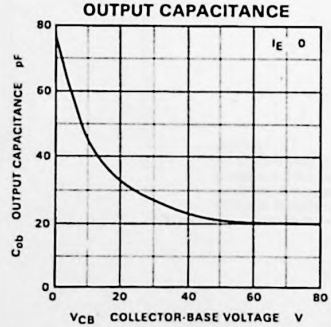
BASE-EMITTER SATURATION VOLTAGE



GAIN BANDWIDTH PRODUCT



OUTPUT CAPACITANCE



POWER TRANSISTOR

NPN SILICON

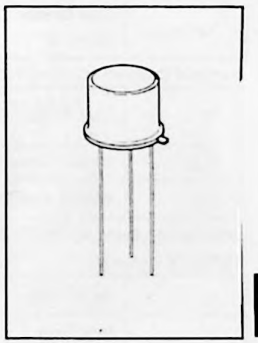
2N5336
2N5337

MEDIUM POWER TRANSISTORS DESIGNED FOR SWITCHING AND WIDE BAND AMPLIFIER APPLICATIONS

- 6.0 W DISSIPATION AT 25°C CASE
- 5.0 A MAXIMUM CONTINUOUS COLLECTOR CURRENT
- 1.2 V $V_{CE(sat)}$ AT 5.0 A

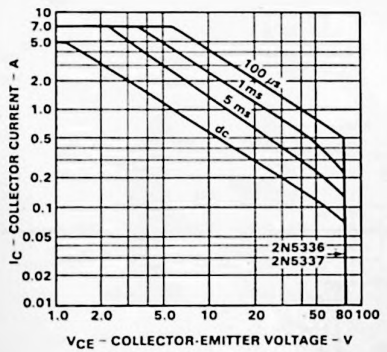
ABSOLUTE MAXIMUM RATINGS (Note 1)

		2N5336	2N5337
Maximum Voltages and Currents			
V_{CEO}	Collector to Emitter Voltage	80 V	80 V
V_{CBO}	Collector to Base Voltage	80 V	80 V
V_{EBO}	Emitter to Base Voltage	6.0 V	6.0 V
I_C	Continuous Collector Current	5.0 A	5.0 A
I_C	Peak Collector Current	7.0 A	7.0 A
I_B	Continuous Base Current	1.0 A	1.0 A
Maximum Power Dissipation			
P_D	Total Dissipation @ 25°C Case Temperature		6.0 W
	Derate linearly from 25°C		34.3 mW/°C
Maximum Temperatures			
T_J, T_{stg}	Storage and Operation Junction Temperatures		−65°C to +200°C
Thermal Characteristics			
$R_{\theta JC}$	Thermal Resistance, Junction to Case		29.2°C/W

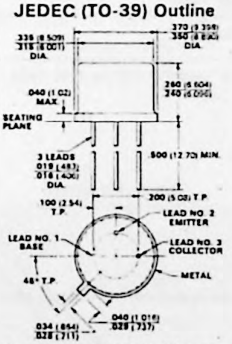


6

SAFE OPERATING AREA



JEDEC (TO-39) Outline

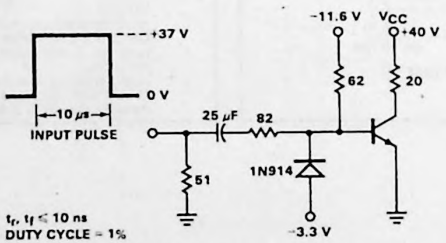


NOTES:
All dimensions in inches (bold) and millimeters (parentheses)
Leads are gold-plated kovar
Lead No. 3 connected to case
Moly disc
High reliability, low thermal resistance
*Dimension the same as JEDEC TO-5 except for lead length
Package weight is 2.9 grams

ELECTRICAL CHARACTERISTICS (25°C Case Temperature unless otherwise noted)

SYMBOL	CHARACTERISTIC	2N5336 MIN	2N5336 MAX	2N5337 MIN	2N5337 MAX	UNIT	TEST CONDITIONS
OFF CHARACTERISTICS							
$V_{CEO(sus)}$	Collector-Emitter Sustaining Voltage (Note 1)	80		80		V	I_C = 50 mA, I_B = 0
I_{CEO}	Collector Cutoff Current		0.1		0.1	mA	V_{CE} = 75 V, I_B = 0
I_{CEX}	Collector Cutoff Current		0.01 1.0		0.01 1.0	mA mA	V_{CE} = 75 V, V_{BE} = −1.5 V V_{CE} = 75 V, V_{BE} = −1.5 V T_C = 150°C
I_{CBO}	Collector Cutoff Current		0.01		0.01	mA	V_{CB} = 80 V, I_E = 0
I_{EBO}	Emitter Cutoff Current		0.1		0.1	mA	V_{EB} = 6.0 V, I_C = 0
ON CHARACTERISTICS							
h_{FE}	DC Current Gain (Note 1)	30 30 20	120	60 60 40	240		I_C = 0.5 A, V_{CE} = 2.0 V I_C = 2.0 A, V_{CE} = 2.0 V I_C = 5.0 A, V_{CE} = 2.0 V
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage (Note 1)		0.7 1.2		0.7 1.2	V V	I_C = 2.0 A, I_B = 0.2 A I_C = 5.0 A, I_B = 0.5 A
$V_{BE(sat)}$	Base-Emitter Saturation Voltage (Note 1)		1.2 1.8		1.2 1.8	V V	I_C = 2.0 A, I_B = 0.2 A I_C = 5.0 A, I_B = 0.5 A
DYNAMIC CHARACTERISTICS							
f_T	Current-Gain-Bandwidth Product	30		30		MHz	I_C = 500 mA, V_{CE} = 10 V, f = 10 MHz
C_{ob}	Output Capacitance		250		250		V_{CB} = 10 V, I_E = 0, f = 0.1 MHz
C_{ib}	Input Capacitance		1000		1000	pF	V_{EB} = 2.0 V, I_C = 0, f = 0.1 MHz
SWITCHING CHARACTERISTICS							
RESISTIVE LOAD							
t_d	Delay Time		0.1		0.1	μs	V_{CC} = 40 V, I_C = 2.0 A, I_{B1} = 200 mA, t_p = 10 μs, Duty Cycle = 1%
t_r	Rise Time		0.1		0.1	μs	
t_s	Storage Time		2.0		2.0	μs	V_{CC} = 40 V, I_C = 2.0 A, I_{B1} = I_{B2} = 200 mA, t_p = 10 μs, Duty Cycle = 1%
t_f	Fall Time		0.2		0.2	μs	

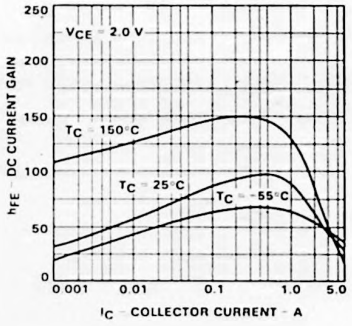
NOTE 1. Pulse conditions: Length = 300 μs, Duty Cycle = 2%.



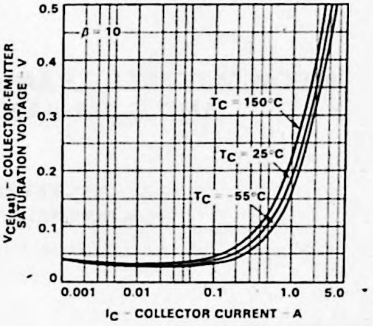
SWITCHING TIME TEST CIRCUIT

TYPICAL ELECTRICAL CHARACTERISTICS

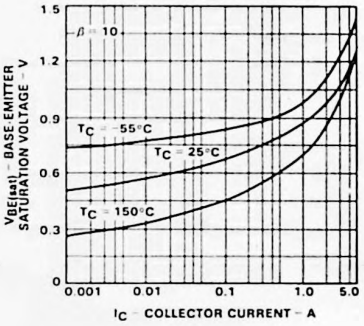
DC CURRENT GAIN



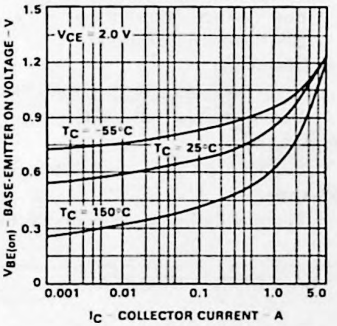
COLLECTOR-EMITTER SATURATION VOLTAGE



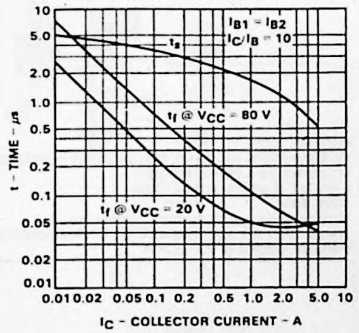
BASE-EMITTER SATURATION VOLTAGE



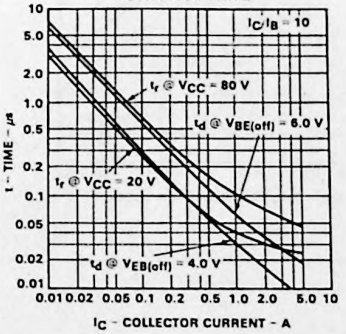
BASE-EMITTER ON VOLTAGE



TURN OFF TIME



TURN ON TIME



POWER TRANSISTOR

NPN SILICON

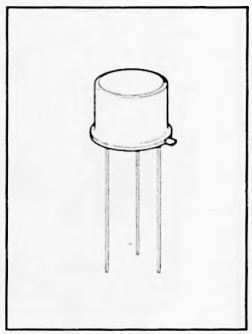
2N5338
2N5339

MEDIUM POWER TRANSISTORS DESIGNED FOR SWITCHING AND WIDE BAND AMPLIFIER APPLICATIONS

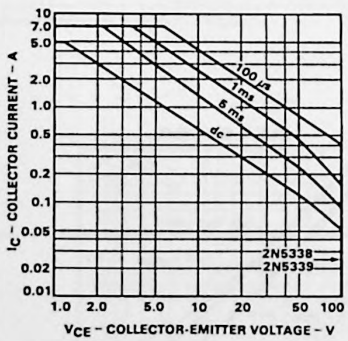
- 6.0 W DISSIPATION AT 25°C CASE
- 5.0 A MAXIMUM CONTINUOUS COLLECTOR CURRENT
- 1.2 V $V_{CE(sat)}$ AT 5.0 A

ABSOLUTE MAXIMUM RATINGS (Note 1)

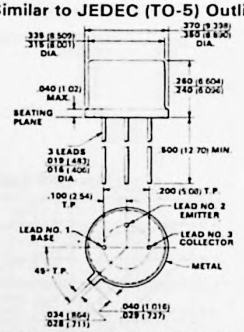
		2N5338	2N5339
Maximum Voltages and Currents			
V_{CEO}	Collector to Emitter Voltage	100 V	100 V
V_{CBO}	Collector to Base Voltage	100 V	100 V
V_{EBO}	Emitter to Base Voltage	6.0 V	6.0 V
I_C	Continuous Collector Current	5.0 A	5.0 A
I_C	Peak Collector Current	7.0 A	7.0 A
I_B	Continuous Base Current	1.0 A	1.0 A
Maximum Power Dissipation			
P_D	Total Dissipation @ 25°C Case Temperature		6.0 W
	Derate linearly from 25°C		34.3 mW/°C
Maximum Temperatures			
T_J, T_{stg}	Storage and Operation Junction Temperatures		−65°C to +200°C
Thermal Characteristics			
$R_{\theta JC}$	Thermal Resistance, Junction to Case		29.2 °C/W



SAFE OPERATING AREA



***Similar to JEDEC (TO-5) Outline**

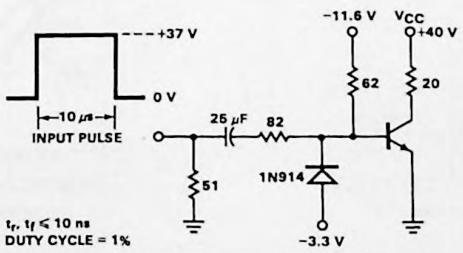


NOTES:
All dimensions in inches (bold) and millimeters (parentheses)
Leads are gold-plated kovar
Lead No. 3 connected to case
Moly disc
High reliability, low thermal resistance
*Dimension the same as JEDEC TO-5 except for lead length
Package weight is 2.9 grams

ELECTRICAL CHARACTERISTICS (25°C Case Temperature unless otherwise noted)

SYMBOL	CHARACTERISTIC	2N5338 MIN	2N5338 MAX	2N5339 MIN	2N5339 MAX	UNIT	TEST CONDITIONS
OFF CHARACTERISTICS							
$V_{CEO(sus)}$	Collector-Emitter Sustaining Voltage (Note 1)	100		100		V	I_C = 50 mA, I_B = 0
I_{CEO}	Collector Cutoff Current		0.1		0.1	mA	V_{CE} = 90 V, I_B = 0
I_{CEX}	Collector Cutoff Current		0.01 1.0		0.01 1.0	mA mA	V_{CE} = 90 V, V_{BE} = −1.5 V V_{CE} = 90 V, V_{BE} = 1.5 V, T_C = 150°C
I_{CBO}	Collector Cutoff Current		0.01		0.01	mA	V_{CB} = 100 V, I_E = 0
I_{EBO}	Emitter Cutoff Current		0.1		0.1	mA	V_{EB} = 6.0 V, I_C = 0
ON CHARACTERISTICS							
h_{FE}	DC Current Gain (Note 1)	30 30 20	120	60 60 40	240		I_C = 0.5 A, V_{CE} = 2.0 V I_C = 2.0 A, V_{CE} = 2.0 V I_C = 5.0 A, V_{CE} = 2.0 V
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage (Note 1)		0.7 1.2		0.7 1.2	V V	I_C = 2.0 A, I_B = 0.2 A I_C = 5.0 A, I_B = 0.5 A
$V_{BE(sat)}$	Base-Emitter Saturation Voltage (Note 1)		1.2 1.8		1.2 1.8	V V	I_C = 2.0 A, I_B = 0.2 A I_C = 5.0 A, I_B = 0.5 A
DYNAMIC CHARACTERISTICS							
f_T	Current-Gain-Bandwidth Product	30		30		MHz	I_C = 500 mA, V_{CE} = 10 V, f = 10 MHz
C_{ob}	Output Capacitance		250		250		V_{CB} = 10 V, I_E = 0, f = 0.1 MHz
C_{ib}	Input Capacitance		1000		1000	pF	V_{EB} = 2.0 V, I_C = 0, f = 0.1 MHz
SWITCHING CHARACTERISTICS							
RESISTIVE LOAD							
t_d	Delay Time		0.1		0.1	μs	V_{CC} = 40 V, I_C = 2.0 A, I_{B1} = 200 mA, t_p = 10 μs, Duty Cycle = 1%
t_r	Rise Time		0.1		0.1	μs	
t_s	Storage Time		2.0		2.0	μs	V_{CC} = 40 V, I_C = 2.0 A, I_{B1} = I_{B2} = 200 mA, t_p = 10 μs, Duty Cycle = 1%
t_f	Fall Time		0.2		0.2	μs	

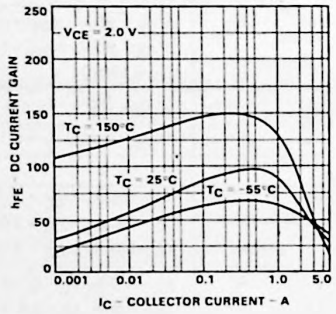
NOTE: 1. Pulse conditions: Length = 300 μs, Duty Cycle = 2%.



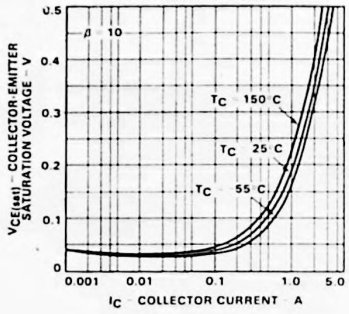
SWITCHING TIME TEST CIRCUIT

TYPICAL ELECTRICAL CHARACTERISTICS

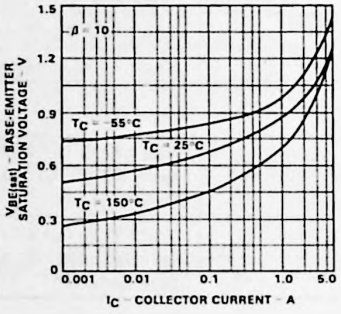
DC CURRENT GAIN



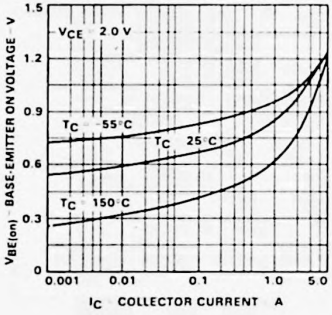
COLLECTOR-EMITTER SATURATION VOLTAGE



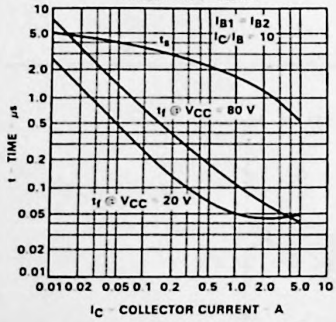
BASE-EMITTER SATURATION VOLTAGE



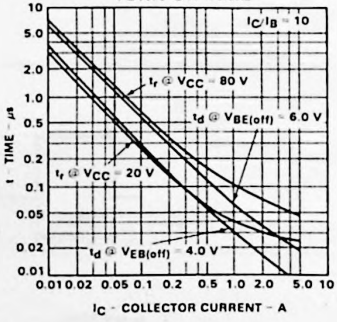
BASE-EMITTER ON VOLTAGE



TURN OFF TIME



TURN ON TIME



POWER TRANSISTOR

PNP SILICON

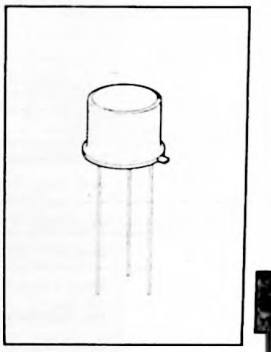
2N5415
2N5416

DESIGNED FOR HIGH-SPEED SWITCHING AND LINEAR-AMPLIFIER APPLICATIONS IN MILITARY, INDUSTRIAL AND COMMERCIAL EQUIPMENT

- 10 W DISSIPATION AT 25°C CASE
- 1 A MAXIMUM CONTINUOUS COLLECTOR CURRENT
- UP TO 350 V V_{CBO} RATING (2N5416)
- COMPLEMENTS TO 2N3439, 2N3440

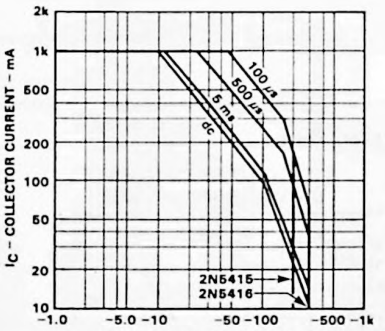
ABSOLUTE MAXIMUM RATINGS

		2N5415	2N5416
Maximum Voltages and Currents			
V_{CE}	Collector to Emitter Voltage	−200 V	−300 V
V_{CB}	Collector to Base Voltage	−200 V	−350 V
V_{EB}	Emitter to Base Voltage	−4.0 V	−4.0 V
I_C	Continuous Collector Current	1.0 A	1.0 A
I_B	Continuous Base Current	0.5 A	0.5 A
Maximum Power Dissipation			
P_D	Total Dissipation @ 25°C Case Temperature		10 W
	Derate Linearly from 25°C		1.14 W/°C
Maximum Temperatures			
T_J, T_{stg}	Storage and Operation Junction Temperatures		−65°C to +200°C
Thermal Characteristics			
$R_{\theta JC}$	Thermal Resistance, Junction to Case		17.5°C/W
T_P	Maximum Lead Temperature (Soldering, 10 s)		255°C

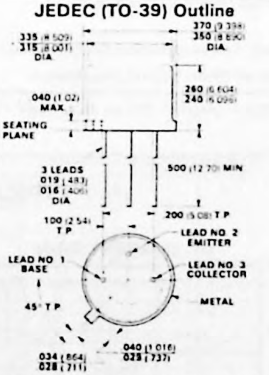


6

SAFE OPERATING AREA



JEDEC (TO-39) Outline



NOTES:
All dimensions in inches (bold) and millimeters (parentheses)
Leads are gold-plated kovar
Lead No. 3 connected to case
Package weight is 0.76 gram

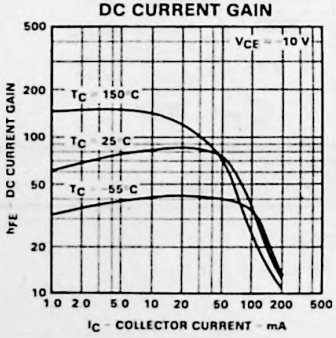
ELECTRICAL CHARACTERISTICS (25°C Case Temperature unless otherwise noted)

SYMBOL	CHARACTERISTICS	2N5415		2N5416		UNIT	TEST CONDITIONS
		MIN	MAX	MIN	MAX		
OFF CHARACTERISTICS							
$V_{CEO(sus)}$	Collector-Emitter Sustaining Voltage (Note 1)	−200		−300		V	I_C = 50 mA, I_B = 0
$V_{CER(sus)}$	Collector-Emitter Sustaining Voltage (Note 1)			−350		V	I_C = 50 mA, R_{BE} = 50 Ω
I_{CEO}	Collector Cutoff Current		50		50	μA μA	V_{CE} = −150 V, I_B = 0 V_{CE} = −250 V, I_B = 0
I_{CEV}	Collector Cutoff Current		50		50	μA μA	V_{CE} = −200 V, V_{BE} = 1.5 V V_{CE} = −300 V, V_{BE} = 1.5 V
I_{CBO}	Collector Cutoff Current		50		50	μA μA	V_{CB} = −175 V, I_E = 0 V_{CB} = −280 V, I_E = 0
I_{EBO}	Emitter Cutoff Current		20		20	μA μA	V_{EB} = −4.0 V, I_C = 0 V_{EB} = −6.0 V, I_C = 0
ON CHARACTERISTICS							
h_{FE}	DC Current Gain (Note 1)	30	150	30	120		I_C = 50 mA, V_{CE} = −10 V
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage (Note 1)		−2.5		−2.0	V	I_C = 50 mA, I_B = 5.0 mA
$V_{BE(on)}$	Base-Emitter "On" Voltage (Note 1)		−1.5		−1.5	V	I_C = 50 mA, V_{CE} = −10 V
SECOND BREAKDOWN							
$I_{S/b}$	Second Breakdown Collector Current with Base Forward Biased	100		100		mA	V_{CE} = −100 V, t = 1.0 s (non repetitive)
DYNAMIC CHARACTERISTICS							
C_{ob}	Output Capacitance		15		15	pF	V_{CB} = −10 V, I_E = 0, f = 1.0 MHz
C_{ib}	Input Capacitance		75		75	pF	V_{EB} = −5.0 V, I_C = 0, f = 1.0 MHz
$\lvert h_{fe} \rvert$	Magnitude of Common Emitter Small Signal Current Gain	3.0		3.0			I_C = 10 mA, V_{CE} = −10 V, f = 5.0 MHz
h_{fe}	Small Signal Current Gain	25		25			I_C = 5.0 mA, V_{CE} = −10 V, f = 1.0 kHz
$R_e(h_{ie})$	Real Part of Common Emitter Small Signal Short-Circuit Impedance		300		300	Ω	I_C = 5.0 mA, V_{CE} = −10 V, f = 1.0 MHz

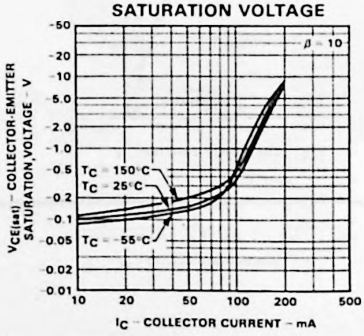
NOTE: 1. Pulse conditions: Length = 300 μs, Duty Cycle = 2%.

TYPICAL ELECTRICAL CHARACTERISTICS

DC CURRENT GAIN

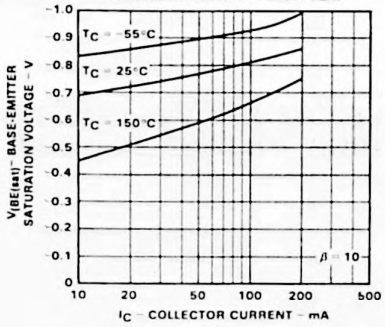


COLLECTOR-EMITTER SATURATION VOLTAGE

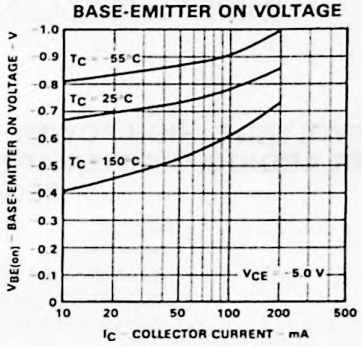


TYPICAL ELECTRICAL CHARACTERISTICS (Cont'd)

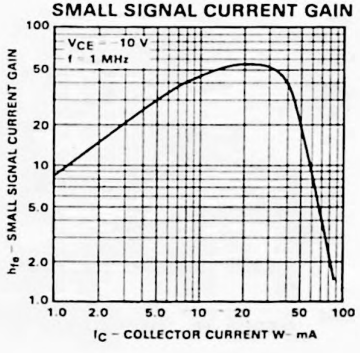
BASE-EMITTER SATURATION VOLTAGE



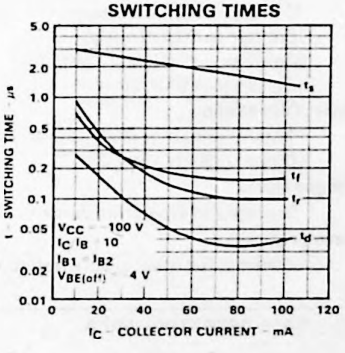
BASE-EMITTER ON VOLTAGE



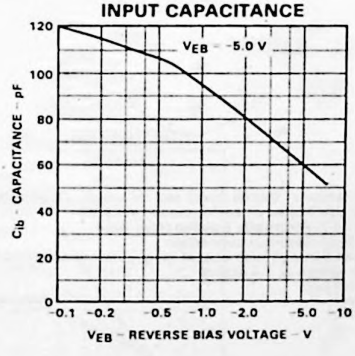
SMALL SIGNAL CURRENT GAIN



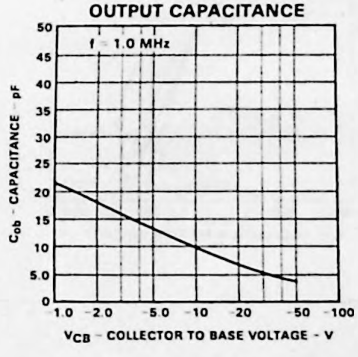
SWITCHING TIMES



INPUT CAPACITANCE



OUTPUT CAPACITANCE



POWER TRANSISTOR

NPN SILICON

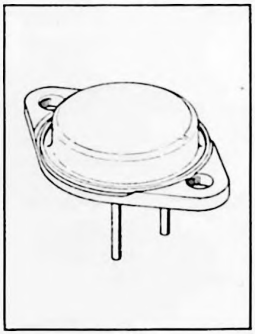
2N5629
2N5630
2N5631

HIGH VOLTAGE, HIGH POWER TRANSISTORS DESIGNED FOR USE IN HIGH POWER AUDIO AMPLIFIER APPLICATIONS AND HIGH VOLTAGE SWITCHING REGULATOR CIRCUITS

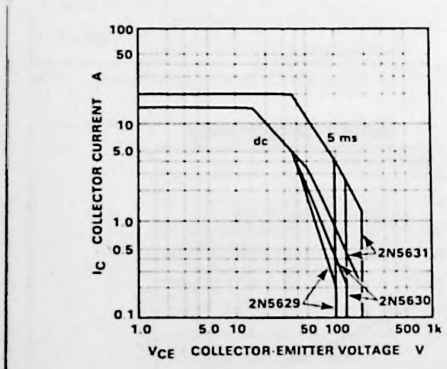
- 200 W DISSIPATION AT 25°C CASE
- 16 A MAXIMUM CONTINUOUS COLLECTOR CURRENT
- HIGH CURRENT h_{FE}, 25-100 @ 8.0 A, 2.0 V (2N5629)

ABSOLUTE MAXIMUM RATINGS (Note 1)

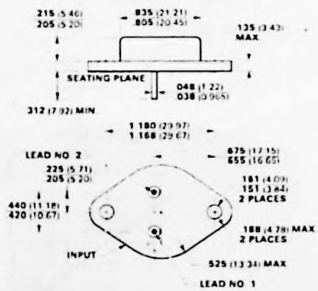
		2N5629	2N5630	2N5631
Maximum Voltages and Currents				
V_{CEO}	Collector to Emitter Voltage	100 V	120 V	140 V
V_{CBO}	Collector to Base Voltage	100 V	120 V	140 V
V_{EBO}	Emitter to Base Voltage	7.0 V	7.0 V	7.0 V
I_C	Continuous Collector Current	16 A	16 A	16 A
I_B	Continuous Base Current	5.0 A	5.0 A	5.0 A
Maximum Power Dissipation				
P_D	Total Dissipation @ 25°C Case Temperature			200 W
	Derate linearly from 25°C			1.14 W/°C
Maximum Temperatures				
T_J, T_{stg}	Storage and Operation Junction Temperatures			−65°C to +200°C
Thermal Characteristics				
$R_{\theta JC}$	Thermal Resistance, Junction to Case			0.875°C/W



SAFE OPERATING AREA



JEDEC (TO-3) Outline



NOTES:
All dimensions in inches (bold) and millimeters (parentheses)
Pins are gold-plated or solder-dipped alloy 52
Pins 1 and 2 electrically isolated from case
Case is third electrical connection
Aluminum package with copper slug, pins are soldered in
Package weight is 7.4 grams
Aluminum cap

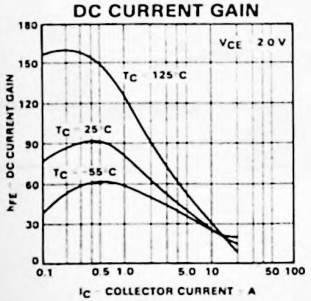
ELECTRICAL CHARACTERISTICS (25°C Case Temperature unless otherwise noted)

SYMBOL	CHARACTERISTIC	2N5629		2N5630		2N5631		UNIT	TEST CONDITIONS
		MIN	MAX	MIN	MAX	MIN	MAX		
OFF CHARACTERISTICS									
$V_{CEO(sus)}$	Collector-Emitter Sustaining Voltage (Note 1)	100		120		140		V	I_C = 200 mA, I_B = 0
I_{CEO}	Collector Cutoff Current		1.0					mA	V_{CE} = 50 V, I_B = 0
					1.0			mA	V_{CE} = 60 V, I_B = 0
							1.0	mA	V_{CE} = 70 V, I_B = 0
I_{CEX}	Collector Cutoff Current		1.0					mA	V_{CE} = 100 V, V_{BE} = −1.5 V
					1.0			mA	V_{CE} = 120 V, V_{BE} = −1.5 V
							1.0	mA	V_{CE} = 140 V, V_{BE} = −1.5 V
			5.0					mA	V_{CE} = 100 V, V_{BE} = −1.5 V, T_C = 150°C
					5.0			mA	V_{CE} = 120 V, V_{BE} = −1.5 V, T_C = 150°C
							5.0	mA	V_{CE} = 140 V, V_{BE} = −1.5 V, T_C = 150°C
I_{CBO}	Collector Cutoff Current		1.0					mA	V_{CB} = 100 V, I_E = 0
					1.0			mA	V_{CB} = 120 V, I_E = 0
							1.0	mA	V_{CB} = 140 V, I_E = 0
I_{EBO}	Emitter Cutoff Current		1.0		1.0		1.0	mA	V_{EB} = 7.0 V, I_C = 0
ON CHARACTERISTICS									
h_{FE}	DC Current Gain (Note 1)	20	100	20	80	15	60		I_C = 8.0 A, V_{CE} = 2.0 V
		4.0		4.0		4.0			I_C = 16 A, V_{CE} = 2.0 V
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage (Note 1)		1.0		1.0		1.0	V	I_C = 10 A, I_B = 1.0 A
			2.0		2.0		2.0	V	I_C = 16 A, I_B = 4.0 A
$V_{BE(sat)}$	Base-Emitter Saturation Voltage (Note 1)		1.8		1.8		1.8	V	I_C = 10 A, I_B = 1.0 A
$V_{BE(on)}$	Base-Emitter "On" Voltage (Note 1)		1.5		1.5		1.5	V	I_C = 8.0 A, V_{CE} = 2.0 V
DYNAMIC CHARACTERISTICS									
C_{ob}	Output Capacitance		500		500		5.0	pF	V_{CB} = 10 V, I_E = 0, f = 0.1 MHz
$\lvert h_{fe} \rvert$	Magnitude of Common Emitter Small Signal Current Gain	2.0		2.0		2.0			I_C = 1.0 A, V_{CE} = 20 V, f = 0.5 MHz
h_{fe}	Small Signal Current Gain	15		15		15			I_C = 4.0 A, V_{CE} = 10 V, f = 1.0 kHz

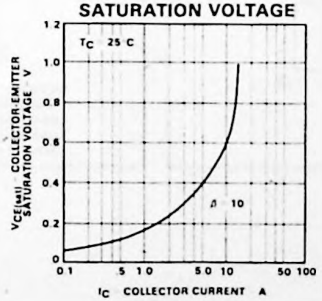
NOTE: 1. Pulse conditions: Length = 300 μs, Duty Cycle = 2%.

TYPICAL ELECTRICAL CHARACTERISTICS

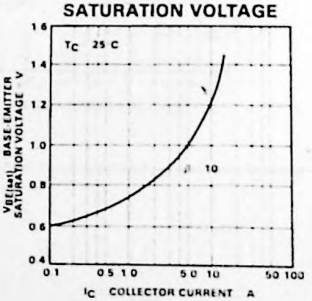
DC CURRENT GAIN



COLLECTOR-EMITTER SATURATION VOLTAGE



BASE-EMITTER SATURATION VOLTAGE



POWER TRANSISTOR

PNP SILICON

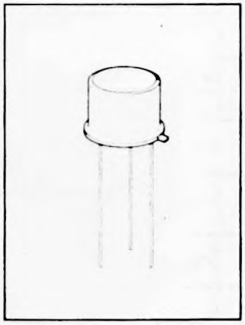
2N5679
2N5680

DESIGNED FOR USE AS A DRIVER FOR HIGH POWER TRANSISTORS IN GENERAL PURPOSE AMPLIFIER AND SWITCHING CIRCUIT APPLICATIONS

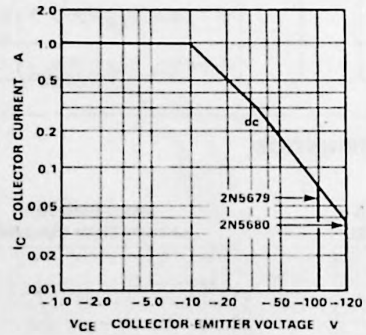
- 10 W DISSIPATION AT 25°C CASE
- 1.0 A MAXIMUM CONTINUOUS COLLECTOR CURRENT
- COMPLEMENT 2N5681, 2N5682

ABSOLUTE MAXIMUM RATINGS (Note 1)

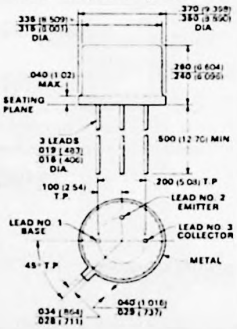
		2N5679	2N5680
Maximum Voltages and Currents			
V_{CEO}	Collector to Emitter Voltage	−100 V	−120 V
V_{CBO}	Collector to Base Voltage	−100 V	−120 V
V_{EBO}	Emitter to Base Voltage	−4.0 V	−4.0 V
I_C	Continuous Collector Current	1.0 A	1.0 A
I_B	Continuous Base Current	0.5 A	0.5 A
Maximum Power Dissipation			
P_D	Total Dissipation @ 25°C Case Temperature		10 W
	Derate Linearly from 25°C		0.057 W/°C
Maximum Temperatures			
T_J, T_{stg}	Storage and Operation Junction Temperatures		−65°C to +200°C
Thermal Characteristics			
$R_{\theta JC}$	Thermal Resistance, Junction to Case		17.5°C/W



SAFE OPERATING AREA



JEDEC (TO-39) Outline



NOTES:
All dimensions in inches (bold) and millimeters (parentheses)
Leads are gold-plated kovar
Lead No. 3 connected to case
Package weight is 0.76 gram

ELECTRICAL CHARACTERISTICS (25°C Case Temperature unless otherwise noted)

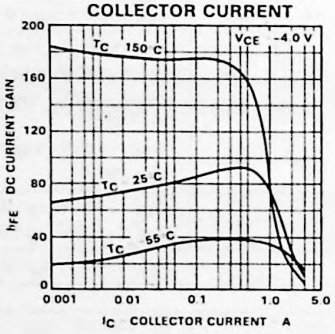
SYMBOL	CHARACTERISTIC	2N5679		2N5680		UNIT	TEST CONDITIONS
		MIN	MAX	MIN	MAX		
OFF CHARACTERISTICS							
$V_{CEO(sus)}$	Collector-Emitter Sustaining Voltage (Note 1)	−100		−120		V	I_C = 10 mA, I_B = 0
I_{CEO}	Collector Cutoff Current		10			μA	V_{CE} = −70 V, I_B = 0
					10	μA	V_{CE} = −80 V, I_B = 0
I_{CEX}	Collector Cutoff Current		1.0			μA	V_{CE} = −100 V, V_{BE} = 1.5 V
					1.0	μA	V_{CE} = −120 V, V_{BE} = 1.5 V
			1.0			mA	V_{CE} = −100 V, V_{BE} = 1.5 V, T_C = 150°C
					1.0	mA	V_{CE} = −120 V, V_{BE} = 1.5 V T_C = 150°C
I_{CBO}	Collector Cutoff Current		1.0			μA	V_{CB} = −100 V, I_E = 0
					1.0	μA	V_{CB} = −120 V, I_E = 0
I_{EBO}	Emitter Cutoff Current		1.0		1.0	μA	V_{EB} = −4.0 V, I_C = 0
ON CHARACTERISTICS							
h_{FE}	DC Current Gain (Note 1)	40	150	40	150		I_C = 250 mA, V_{CE} = −2.0 V
		5.0		5.0			I_C = 1.0 A, V_{CE} = −2.0 V
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage (Note 1)		−0.6		−0.6	V	I_C = 250 mA, I_B = 25 mA
			−1.0		−1.0	V	I_C = 500 mA, I_B = 50 mA
			−2.0		−2.0	V	I_C = 1.0 A, I_B = 200 mA
$V_{BE(on)}$	Base-Emitter "On" Voltage (Note 1)		−1.0		−1.0	V	I_C = 250 mA, V_{CE} = −2.0 V
DYNAMIC CHARACTERISTICS							
f_T	Current-Gain-Bandwidth Product	30		30		MHz	I_C = 100 mA, V_{CE} = −10 V, f = 10 MHz
C_{ob}	Output Capacitance		50		50	pF	V_{CB} = −20 V, I_E = 0, f = 1.0 MHz
h_{fe}	Small Signal Current Gain	40		40			I_C = 200 mA, V_{CE} = −1.5 V, f = 1.0 kHz

NOTE: 1. Pulse conditions: Length = 300 μs, Duty Cycle = 2%.

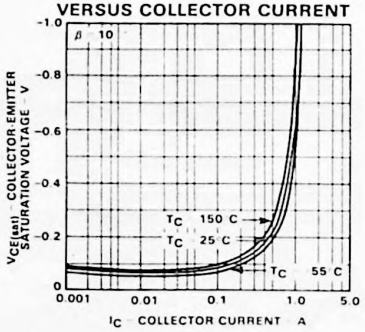
6

TYPICAL ELECTRICAL CHARACTERISTICS

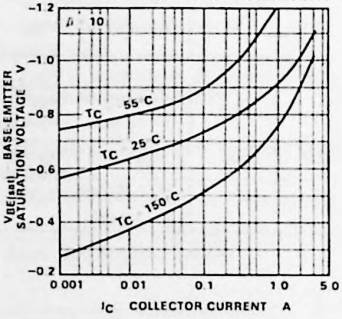
CURRENT GAIN VERSUS COLLECTOR CURRENT



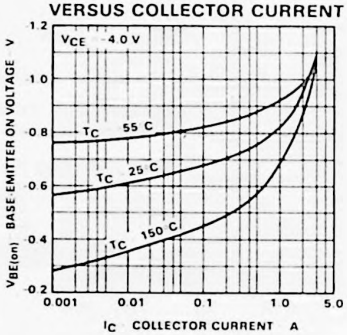
COLLECTOR SATURATION VOLTAGE VERSUS COLLECTOR CURRENT



BASE SATURATION VOLTAGE VERSUS COLLECTOR CURRENT



BASE-EMITTER ON VOLTAGE VERSUS COLLECTOR CURRENT



POWER TRANSISTOR

NPN SILICON

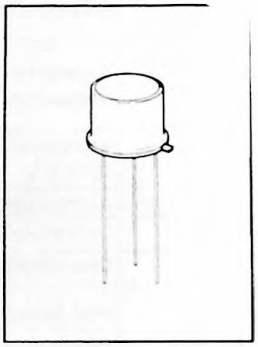
2N5681
2N5682

DESIGNED FOR USE AS A DRIVER FOR HIGH POWER TRANSISTORS IN GENERAL PURPOSE AMPLIFIER AND SWITCHING CIRCUIT APPLICATIONS

- 10 W DISSIPATION AT 25°C CASE
- 1.0 A MAXIMUM CONTINUOUS COLLECTOR CURRENT
- COMPLEMENTS 2N5679, 2N5680

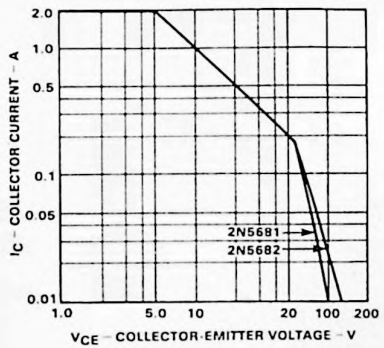
ABSOLUTE MAXIMUM RATINGS (Note 1)

		2N5681	2N5682
Maximum Voltages and Currents			
V_{CEO}	Collector to Emitter Voltage	100 V	120 V
V_{CBO}	Collector to Base Voltage	100 V	120 V
V_{EBO}	Emitter to Base Voltage	4.0 V	4.0 V
I_C	Continuous Collector Current	1.0 A	1.0 A
I_B	Continuous Base Current	0.5 A	0.5 A
Maximum Power Dissipation			
P_D	Total Dissipation @ 25°C Case Temperature		10 W
	Derate Linearly from 25°C		0.057 W/°C
Maximum Temperatures			
T_J, T_{stg}	Storage and Operation Junction Temperatures		−65°C to +200°C
Thermal Characteristics			
$R_{\theta JC}$	Thermal Resistance, Junction to Case		17.5°C/W

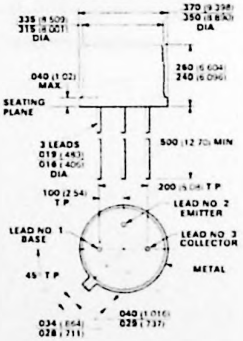


6

SAFE OPERATING AREA



JEDEC (TO-39) Outline



NOTES:
All dimensions in inches (bold) and millimeters (parentheses)
Leads are gold-plated kovar
Lead No. 3 connected to case
Package weight is 0.76 gram

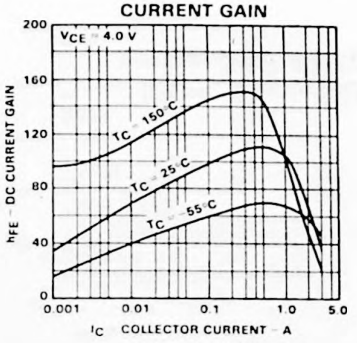
ELECTRICAL CHARACTERISTICS (25°C Case Temperature unless otherwise noted)

SYMBOL	CHARACTERISTIC	2N5681		2N5682		UNIT	TEST CONDITIONS
		MIN	MAX	MIN	MAX		
OFF CHARACTERISTICS							
$V_{CEO(sus)}$	Collector-Emitter Sustaining Voltage (Note 1)	100		120		V	I_C = 10 mA, I_B = 0
I_{CEO}	Collector Cutoff Current		10			μA	V_{CE} = 70 V, I_B = 0
					10	μA	V_{CE} = 80 V, I_B = 0
I_{CEX}	Collector Cutoff Current		1.0			μA	V_{CE} = 100 V, V_{BE} = −1.5 V
					1.0	μA	V_{CE} = 120 V, V_{BE} = −1.5 V
			1.0			mA	V_{CE} = 100 V, V_{BE} = −1.5 V, T_C = 150°C
					1.0	mA	V_{CE} = 120 V, V_{BE} = −1.5 V, T_C = 150°C
I_{CBO}	Collector Cutoff Current		1.0			μA	V_{CB} = 100 V, I_E = 0
					1.0	μA	V_{CB} = 120 V, I_E = 0
I_{EBO}	Emitter Cutoff Current		1.0		1.0	μA	V_{EB} = 4.0 V, I_C = 0
ON CHARACTERISTICS							
h_{FE}	DC Current Gain (Note 1)	40	150	40	150		I_C = 250 mA, V_{CE} = 2.0 V
		5.0		5.0			I_C = 1.0 A, V_{CE} = 2.0 V
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage (Note 1)		0.6		0.6	V	I_C = 250 mA, I_B = 25 mA
			1.0		1.0	V	I_C = 500 mA, I_B = 50 mA
			2.0		2.0	V	I_C = 1.0 A, I_B = 200 mA
$V_{BE(on)}$	Base-Emitter "On" Voltage (Note 1)		1.0		1.0	V	I_C = 250 mA, V_{CE} = 2.0 V
DYNAMIC CHARACTERISTICS							
f_T	Current-Gain-Bandwidth Product	30		30		MHz	I_C = 100 mA, V_{CE} = 10 V, f = 10 MHz
C_{ob}	Output Capacitance		50		50	pF	V_{CB} = 20 V, I_E = 0, f = 1.0 MHz
h_{fe}	Small Signal Current Gain	4.0		4.0			I_C = 200 mA, V_{CE} = 1.5 V, f = 1.0 kHz

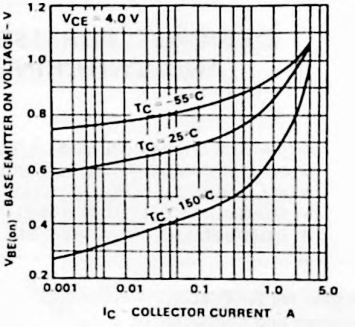
NOTE 1. Pulse conditions: Length = 300 μs, Duty Cycle = 2%.

TYPICAL ELECTRICAL CHARACTERISTICS

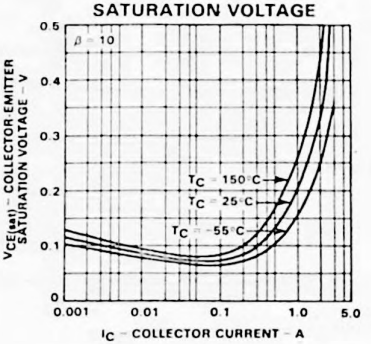
CURRENT GAIN



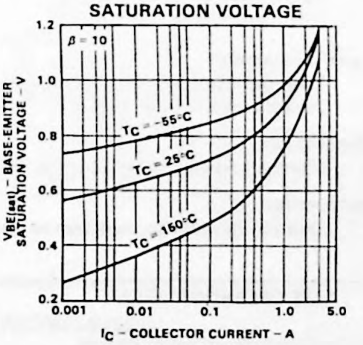
BASE-EMITTER ON VOLTAGE VERSUS COLLECTOR CURRENT



COLLECTOR-EMITTER SATURATION VOLTAGE



BASE-EMITTER SATURATION VOLTAGE



6

POWER TRANSISTOR

PNP SILICON

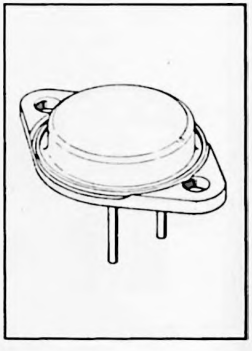
2N5683
2N5684

DESIGNED FOR USE IN HIGH-POWER AMPLIFIER AND SWITCHING CIRCUIT APPLICATIONS

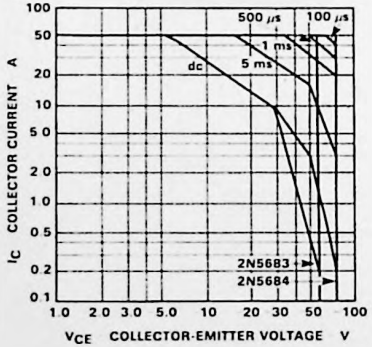
- 300 W DISSIPATION AT 25°C CASE
- 50 A MAXIMUM CONTINUOUS COLLECTOR CURRENT
- MAXIMUM DC CURRENT GAIN OF 60 AT 25 A I_C
- MAXIMUM COLLECTOR-EMITTER SATURATION VOLTAGE OF 1.0 V AT 25 A I_C
- COMPLEMENT TO 2N5685, 2N5686

ABSOLUTE MAXIMUM RATINGS

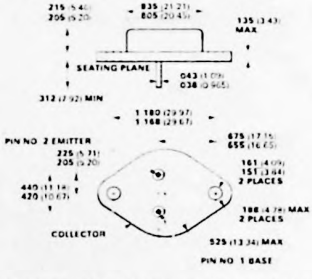
		2N5683	2N5684
Maximum Voltages and Currents			
V_{CE}	Collector to Emitter Voltage	−60 V	−80 V
V_{CB}	Collector to Base Voltage	−60 V	−80 V
V_{EB}	Emitter to Base Voltage	−5.0 V	−5.0 V
I_C	Continuous Collector Current	50 A	50 A
I_B	Continuous Base Current	15 A	15 A
Maximum Power Dissipation			
P_D	Total Dissipation @ 25°C Case Temperature		300 W
	Derate Linearly from 25°C		.085 W/°C
Maximum Temperatures			
T_J, T_{stg}	Storage and Operation Junction Temperatures		−65°C to +200°C
Thermal Characteristics			
$R_{\theta JC}$	Thermal Resistance, Junction to Case		0.584°C/W



SAFE OPERATING AREA



JEDEC (TO-3) Outline



NOTES:
All dimensions in inches (bold) and millimeters (parentheses)
Pins are alloy-52
Pins 1 and 2 electrically isolated from case
Case is third electrical connection
Copper base with soldered in pins
Aluminum cap
Package weight is 17.9 grams

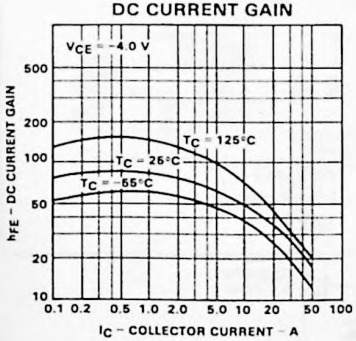
ELECTRICAL CHARACTERISTICS (25°C Case Temperature unless otherwise noted)

SYMBOL	CHARACTERISTIC	2N5683		2N5684		UNIT	TEST CONDITIONS
		MIN	MAX	MIN	MAX		
OFF CHARACTERISTICS							
$V_{CEO(sus)}$	Collector-Emitter Sustaining Voltage (Note 1)	−60		−80		V	I_C = 200 mA, I_B = 0
I_{CEO}	Collector Cutoff Current		1.0		1.0	mA	V_{CE} = −30 V, I_B = 0 V_{CE} = −40 V, I_B = 0
I_{CEX}	Collector Cutoff Current		2.0		2.0	mA mA	V_{CE} = −60 V, V_{BE} = 1.5 V, V_{CE} = −80 V, V_{BE} = 1.5 V,
			10		10	mA mA	V_{CE} = −60 V, V_{BE} = 1.5 V, T_C = 150°C V_{CE} = −80 V, V_{BE} = 1.5 V, T_C = 150°C
I_{CBO}	Collector Cutoff Current		2.0		2.0	mA mA	V_{CB} = −60 V, I_E = 0 V_{CB} = −80 V, I_E = 0
I_{EBO}	Emitter Cutoff Current		5.0		5.0	mA	V_{EB} = −5.0 V, I_C = 0
ON CHARACTERISTICS							
h_{FE}	DC Current Gain (Note 1)	15 5.0	60	15 5.0	60		I_C = 25 A, V_{CE} = −2.0 V I_C = 50 A, V_{CE} = −5.0 V
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage (Note 1)		−1.0 −5.0		−1.0 −5.0	V V	I_C = 25 A, I_B = 2.5 mA I_C = 50 A, I_B = 10 mA
$V_{BE(sat)}$	Base-Emitter Saturation Voltage (Note 1)		−2.0		−2.0	V	I_C = 25 A, I_B = 2.5 mA
$V_{BE(on)}$	Base-Emitter "On" Voltage (Note 1)		−2.0		−2.0	V	I_C = 25 A, V_{CE} = −2.0 V
DYNAMIC CHARACTERISTICS							
f_T	Current Gain Bandwidth Product	2.0		2.0		MHz	I_C = 5.0 A, V_{CE} = −10 V, f = 1.0 MHz
C_{ob}	Output Capacitance		2000		2000	pF	V_{CB} = −10 V, I_E = 0, f = 0.1 MHz
h_{fe}	Small Signal Current Gain	15		15			I_C = 10 A, V_{CE} = −5.0 V, f = 1.0 kHz

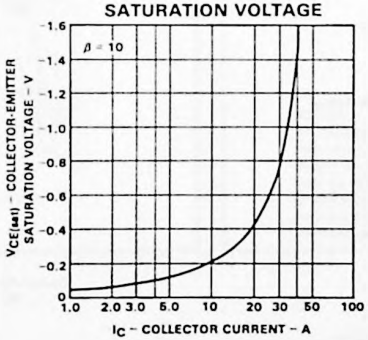
NOTE 1. Pulse conditions: Length = 300 μs, Duty Cycle = 2%.

TYPICAL ELECTRICAL CHARACTERISTICS

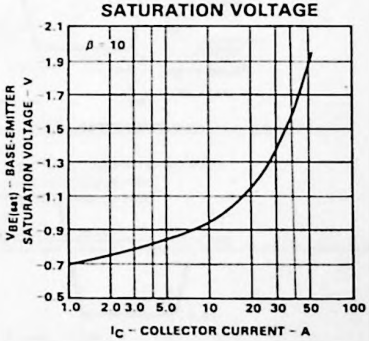
DC CURRENT GAIN



COLLECTOR-EMITTER SATURATION VOLTAGE

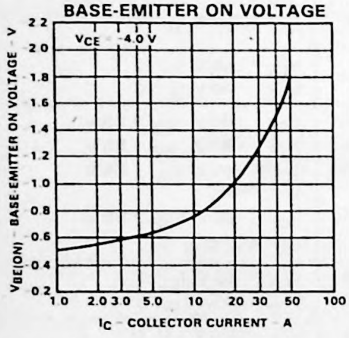


BASE-EMITTER SATURATION VOLTAGE

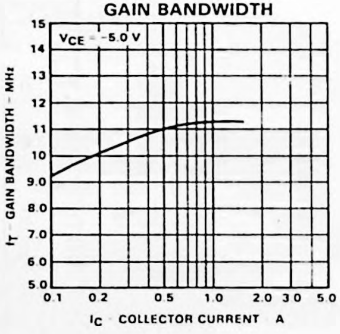


TYPICAL ELECTRICAL CHARACTERISTICS (Cont'd)

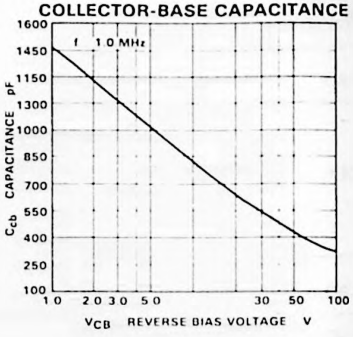
BASE-EMITTER ON VOLTAGE



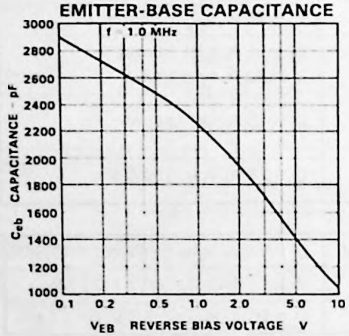
GAIN BANDWIDTH



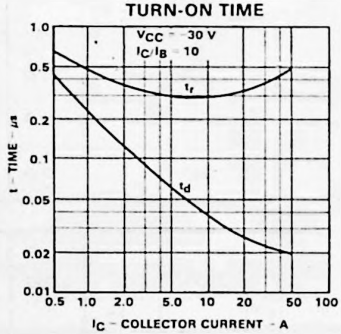
COLLECTOR-BASE CAPACITANCE



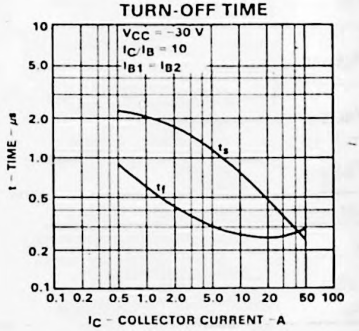
EMITTER-BASE CAPACITANCE



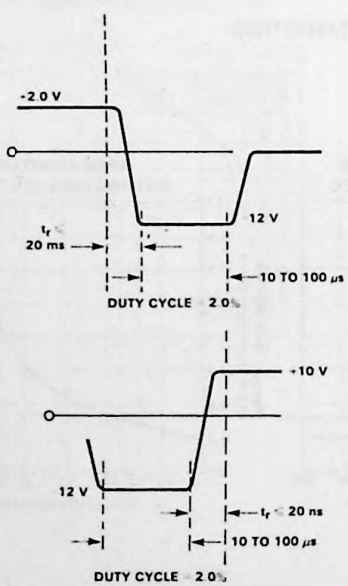
TURN-ON TIME

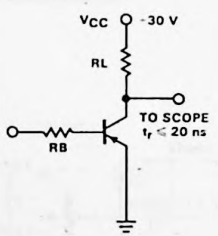


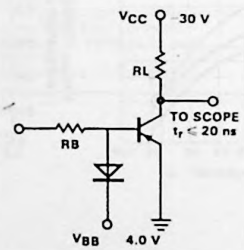
TURN-OFF TIME



SWITCHING CIRCUIT







POWER TRANSISTOR

NPN SILICON

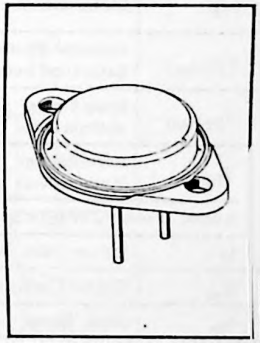
2N5685
2N5686

DESIGNED FOR USE IN HIGH-POWER AMPLIFIER AND SWITCHING CIRCUIT APPLICATIONS

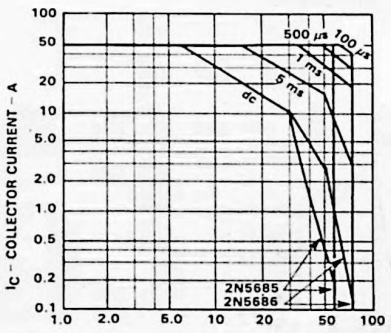
- 300 W DISSIPATION AT 25°C CASE
- 50 A MAXIMUM CONTINUOUS COLLECTOR CURRENT
- MAXIMUM DC CURRENT GAIN OF 60 AT I_C = 25 A
- MAXIMUM COLLECTOR-EMITTER SATURATION VOLTAGE OF 1.0 V AT 25 A I_C
- COMPLEMENT TO 2N5683, 2N5684

ABSOLUTE MAXIMUM RATINGS

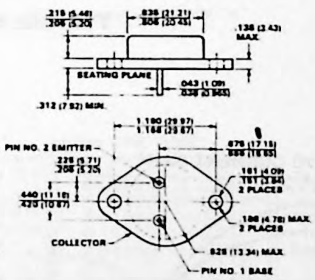
		2N5685	2N5686
Maximum Voltages and Currents			
V_{CE}	Collector to Emitter Voltage	60 V	80 V
V_{CB}	Collector to Base Voltage	60 V	80 V
V_{EB}	Emitter to Base Voltage	5.0 V	5.0 V
I_C	Continuous Collector Current	50 A	50 A
I_B	Continuous Base Current	15 A	15 A
Maximum Power Dissipation			
P_D	Total Dissipation @ 25°C Case Temperature		300 W
	Derate Linearly from 25°C		0.085 W/°C
Maximum Temperatures			
T_J, T_{stg}	Storage and Operation Junction Temperatures		−65°C to +200°C
Thermal Characteristics			
$R_{\theta JC}$	Thermal Resistance, Junction to Case		0.584°C/W



SAFE OPERATING AREA



JEDEC (TO-3) Outline



NOTES:
All dimensions in inches (hold) and millimeters (parentheses)
Pins are alloy-52
Pins 1 and 2 electrically isolated from case
Case is third electrical connection
Copper base with soldered in pins
Aluminum cap
Package weight is 17.9 grams

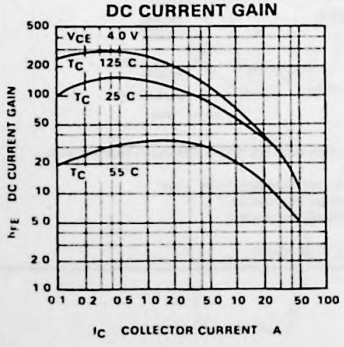
ELECTRICAL CHARACTERISTICS (25°C Case Temperature unless otherwise noted)

SYMBOL	CHARACTERISTIC	2N5685		2N5686		UNIT	TEST CONDITIONS
		MIN	MAX	MIN	MAX		
OFF CHARACTERISTICS							
$V_{CEO(sus)}$	Collector-Emitter Sustaining Voltage (Note 1)	60		80		V	I_C = 200 mA, I_B = 0
I_{CEO}	Collector Cutoff Current		1.0		1.0	mA	V_{CE} = 30 V, I_B = 0 V_{CE} = 40 V, I_B = 0
I_{CEX}	Collector Cutoff Current		2.0 1.0		2.0 1.0	mA	V_{CE} = 60 V, V_{BE} = 1.5 V V_{CE} = 80 V, V_{BE} = 1.5 V V_{CE} = 60 V, V_{BE} = 1.5 V, T_C = 150°C V_{CE} = 80 V, V_{BE} = 1.5 V, T_C = 150°C
I_{CBO}	Collector Cutoff Current		2.0		2.0	mA	V_{CB} = 60 V, I_E = 0 V_{CB} = 80 V, I_E = 0
I_{EBO}	Emitter Cutoff Current		5.0		5.0	mA	V_{EB} = 5.0 V, I_C = 0
ON CHARACTERISTICS							
h_{FE}	DC Current Gain (Note 1)	15 5.0	60	15 5.0	60		I_C = 25 A, V_{CE} = 2.0 V I_C = 50 A, V_{CE} = 5.0 V
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage (Note 1)		1.0 5.0		1.0 5.0	V	I_C = 25 A, I_B = 2.5 A I_C = 50 A, I_B = 10 A
$V_{BE(sat)}$	Base-Emitter Saturation Voltage (Note 1)		2.0		2.0	V	I_C = 25 A, I_B = 2.5 A
$V_{BE(on)}$	Base-Emitter "On" Voltage Voltage (Note 1)		2.0		2.0	V	I_C = 25 A, V_{CE} = 2.0 V
DYNAMIC CHARACTERISTICS							
f_T	Current Gain Bandwidth Product	2.0		2.0		MHz	I_C = 5.0 A, V_{CE} = 10 V, f = 1.0 MHz
C_{ob}	Output Capacitance		1.2 k		1.2 k	pF	V_{CB} = 10 V, I_E = 0, f = 0.1 MHz
h_{fe}	Small Signal Current Gain	15		15			I_C = 10 A, V_{CE} = 5.0 V, f = 1.0 kHz

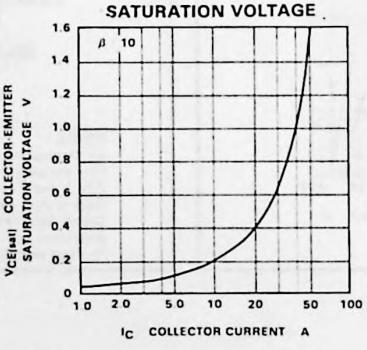
NOTE: 1. Pulse conditions: Length = 300 μs, Duty Cycle = 2%.

TYPICAL ELECTRICAL CHARACTERISTICS

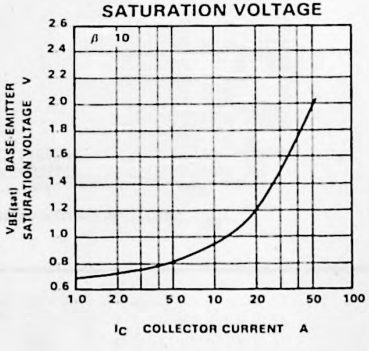
DC CURRENT GAIN



COLLECTOR-EMITTER SATURATION VOLTAGE

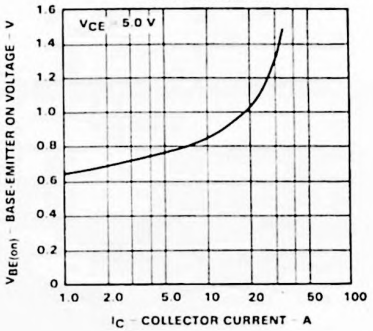


BASE-EMITTER SATURATION VOLTAGE

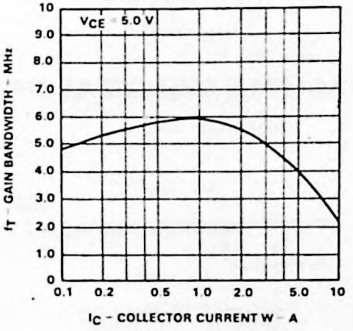


TYPICAL ELECTRICAL CHARACTERISTICS (Cont'd)

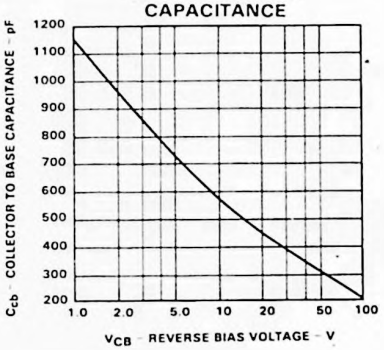
BASE-EMITTER ON VOLTAGE



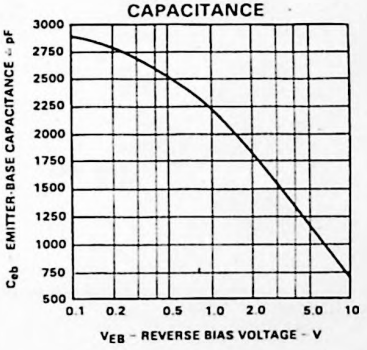
GAIN BANDWIDTH



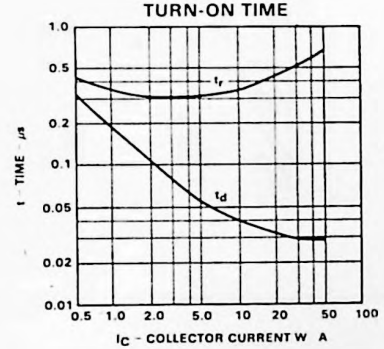
COLLECTOR-BASE CAPACITANCE



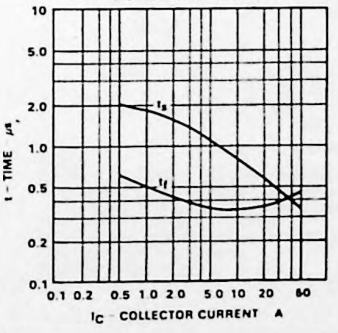
EMITTER-BASE CAPACITANCE



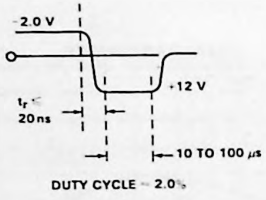
TURN-ON TIME



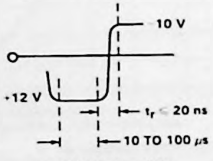
TURN-OFF TIME



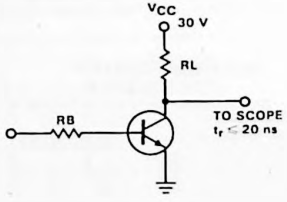
SWITCHING CIRCUIT

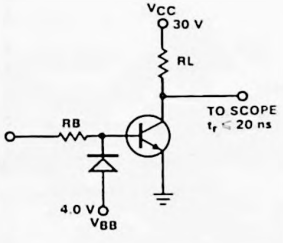


DUTY CYCLE ≈ 2.0%



DUTY CYCLE ≈ 2.0%





POWER TRANSISTOR

NPN SILICON

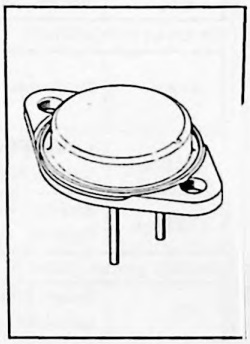
2N5838
2N5839
2N5840

DESIGNED FOR HIGH VOLTAGE POWER SWITCHING APPLICATIONS

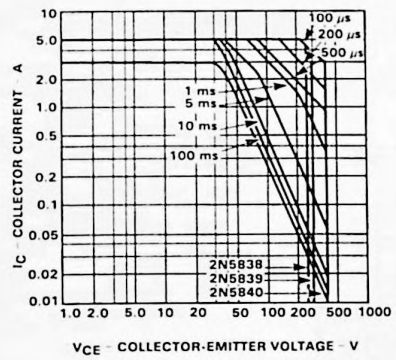
- HIGH SPEED 3.0 A SWITCH
- 3.0 μs t_s @ 3.0 A (2N5838)
- 100 W DISSIPATION AT 25°C CASE
- 3.0 A MAXIMUM CONTINUOUS COLLECTOR CURRENT

ABSOLUTE MAXIMUM RATINGS (Note 1)

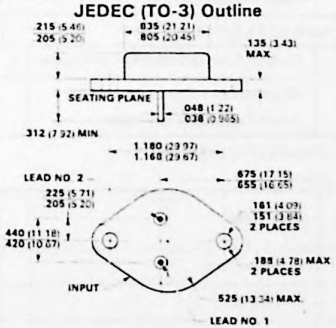
		2N5838	2N5839	2N5840
Maximum Voltages and Currents				
V_{CEO}	Collector to Emitter Voltage	250 V	275 V	350 V
V_{CBO}	Collector to Base Voltage	275 V	300 V	375 V
V_{EBO}	Emitter to Base Voltage	6.0 V	6.0 V	6.0 V
I_C	Continuous Collector Current	3.0 A	3.0 A	3.0 A
I_C	Peak Collector Current	5.0 A	5.0 A	5.0 A
I_B	Continuous Base Current	1.5 A	1.5 A	1.5 A
Maximum Power Dissipation				
P_D	Total Dissipation @ 25°C Case Temperature			100 W
	Derate Linearly from 25°C			0.57 W/°C
Maximum Temperatures				
T_J, T_{stg}	Storage and Operation Junction Temperatures			−65°C to +200°C
Thermal Characteristics				
$R_{\theta JC}$	Thermal Resistance, Junction to Case			1.75°C/W
T_p	Maximum Pin Temperature for Soldering Purposes: 1/8" from Case for 10 seconds			230°C



SAFE OPERATING AREA



JEDEC (TO-3) Outline



NOTES:
All dimensions in inches (bold) and millimeters (parentheses)
Pins are gold-plated or solder-dipped alloy 52
Pins 1 and 2 electrically isolated from case
Case is third electrical connection
Aluminum package with copper slug, pins are soldered in
Package weight is 7.4 grams
Aluminum cap

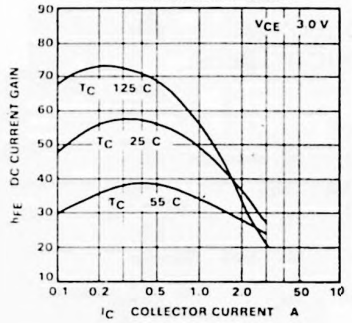
ELECTRICAL CHARACTERISTICS (25°C Case Temperature unless otherwise noted)

SYMBOL	CHARACTERISTIC	2N5838		2N5839		2N5840		UNIT	TEST CONDITIONS
		MIN	MAX	MIN	MAX	MIN	MAX		
OFF CHARACTERISTICS									
$V_{CEO(sus)}$	Collector-Emitter Sustaining Voltage (Note 1)	250		275		350		V	I_C = 200 mA, I_B = 0
$V_{CEX(sus)}$	Collector-Emitter Sustaining Voltage (Note 1)	275		300		375		V	I_C = 100 mA, $V_{BE(off)}$ = −1.5 V
I_{CEO}	Collector Cutoff Current		2.0					mA	V_{CE} = 200 V, I_B = 0
					2.0		2.0	mA	V_{CE} = 250 V, I_B = 0
I_{CEX}	Collector Cutoff Current		5.0					mA	V_{CE} = 265 V, V_{BE} = −1.5 V
					2.0			mA	V_{CE} = 290 V, V_{BE} = −1.5 V
							2.0	mA	V_{CE} = 360 V, V_{BE} = −1.5 V
			8.0					mA	V_{CE} = 265 V, V_{BE} = −1.5 V, T_C = 100°C
					5.0			mA	V_{CE} = 290 V, V_{BE} = −1.5 V, T_C = 100°C
							5.0	mA	V_{CE} = 360 V, V_{BE} = −1.5 V, T_C = 100°C
I_{EBO}	Emitter Cutoff Current		1.0		1.0		1.0	mA	V_{EB} = 6.0 V, I_C = 0
ON CHARACTERISTICS									
h_{FE}	DC Current Gain (Note 1)	20		20		20			I_C = 0.5 A, V_{CE} = 5.0 V
				10	50	10	50		I_C = 2.0 A, V_{CE} = 3.0 V
		8.0	40						I_C = 3.0 A, V_{CE} = 2.0 V
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage (Note 1)		1.0					V	I_C = 3.0 A, I_B = 375 mA
					1.5		1.5	V	I_C = 2.0 A, I_B = 200 mA
$V_{BE(sat)}$	Base-Emitter Saturation Voltage (Note 1)		2.0					V	I_C = 3.0 A, I_B = 375 mA
					2.0		2.0	V	I_C = 2.0 A, I_B = 200 mA
SECOND BREAKDOWN									
$I_{S/b}$	Second Breakdown Collector Current with base forward biased	2.5		2.5		2.5		A	t = 1.0s (non repetitive) V_{CE} = 40 V
$E_{S/b}$	Second Breakdown Energy with base reversed biased	0.45		0.45		0.45		mJ	$V_{BE(off)}$ = −4.0 V, L = 100 μH, R_B = 50 Ω
DYNAMIC CHARACTERISTICS									
C_{ob}	Output Capacitance		150		150		150	pF	V_{CB} = 10 V, I_E = 0, f = 1.0 MHz
$\lvert h_{fe} \rvert$	Magnitude of Common Emitter Small Signal Current Gain	5.0		5.0		5.0			I_C = 200 mA, V_{CE} = 10 V, f = 1.0 MHz
SWITCHING CHARACTERISTICS									
RESISTIVE LOAD									
t_r	Rise Time		1.5					μs	V_{CC} = 200 V, I_C = 3.0 A, I_{B1} = 375 mA
t_s	Storage Time		3.0					μs	V_{CC} = 200 V, I_C = 3.0 A, I_{B1} = I_{B2} = 375 mA
t_f	Fall Time		1.5					μs	
t_r	Rise Time				1.5		1.75	μs	V_{CC} = 200 V, I_C = 2.0 A, I_{B1} = 200 mA, t_p = 20 μs, Duty Cycle = 100 Hz
t_s	Storage Time				3.75		3.0	μs	V_{CC} = 200 V, I_C = 2.0 A, I_{B1} = I_{B2} = 200 mA, t_p = 20 μs Duty Cycle = 100 Hz
t_f	Fall Time				1.5		1.5	μs	

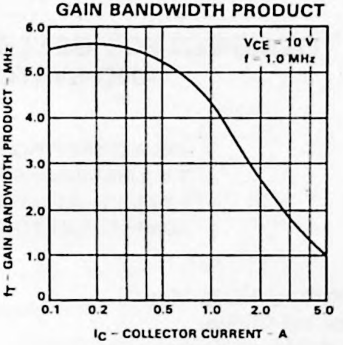
NOTE 1. Pulse conditions: Length = 300 μs, Duty Cycle = 2%

TYPICAL ELECTRICAL CHARACTERISTICS

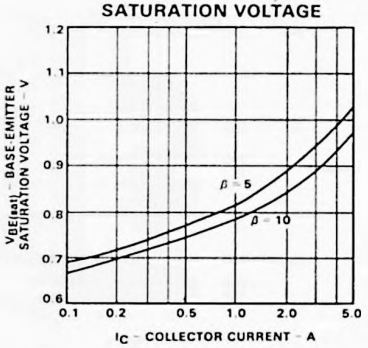
DC CURRENT GAIN



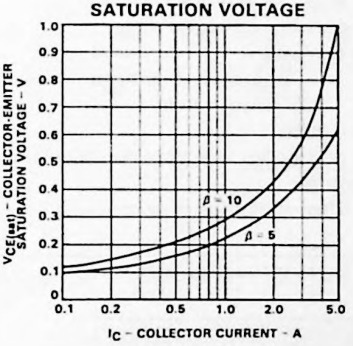
GAIN BANDWIDTH PRODUCT



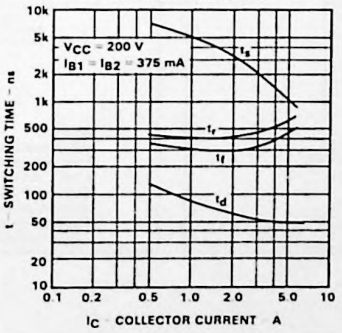
BASE-EMITTER SATURATION VOLTAGE



COLLECTOR-EMITTER SATURATION VOLTAGE



SWITCHING TIMES



6

POWER TRANSISTOR

PNP SILICON

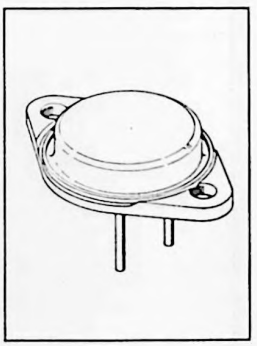
2N5871
2N5872

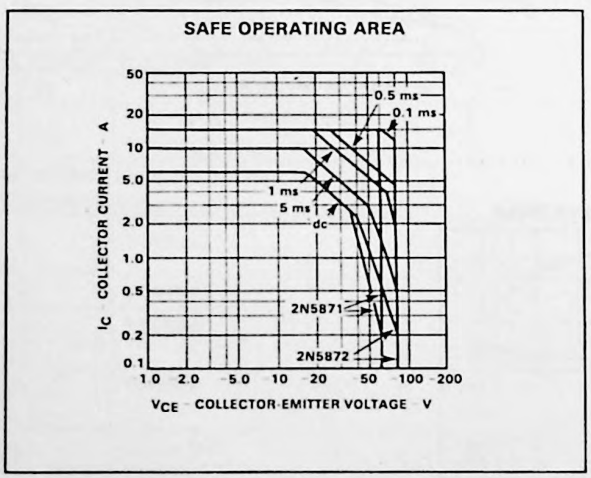
DESIGNED FOR GENERAL PURPOSE POWER AMPLIFIER AND SWITCHING APPLICATIONS

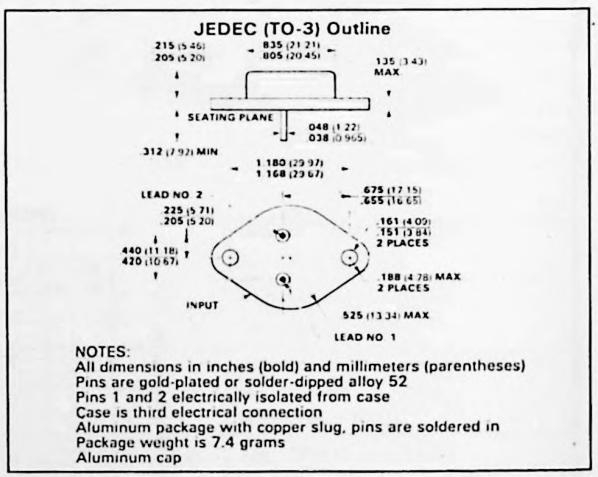
- 115 W DISSIPATION AT 25°C CASE
- 7.0 A MAXIMUM CONTINUOUS COLLECTOR CURRENT
- 4.0 MHz f_T AT 0.25 mAdc COLLECTOR CURRENT
- COMPLEMENT TO 2N5873, 2N5874

ABSOLUTE MAXIMUM RATINGS (Note 1)

		2N5871	2N5872
Maximum Voltages and Currents			
V_{CEO}	Collector to Emitter Voltage	−60 V	−80 V
V_{CBO}	Collector to Base Voltage	−60 V	−80 V
V_{EBO}	Emitter to Base Voltage	−5.0 V	−5.0 V
I_C	Continuous Collector Current	7.0 A	7.0 A
I_C	Peak Collector Current	15 A	15 A
I_B	Continuous Base Current	2.0 A	2.0 A
Maximum Power Dissipation			
P_D	Total Dissipation @ 25°C Case Temperature		115 W
	Derate Linearly from 25°C		0.66 W/°C
Maximum Temperatures			
T_J, T_{stg}	Storage and Operation Junction Temperatures		−65 to +200°C
Thermal Characteristics			
$R_{\theta JC}$	Thermal Resistance, Junction to Case		1.52°C/W







NOTES:
All dimensions in inches (bold) and millimeters (parentheses)
Pins are gold-plated or solder-dipped alloy 52
Pins 1 and 2 electrically isolated from case
Case is third electrical connection
Aluminum package with copper slug, pins are soldered in
Package weight is 7.4 grams
Aluminum cap

ELECTRICAL CHARACTERISTICS ($25^{\circ}C$ Case Temperature unless otherwise noted)

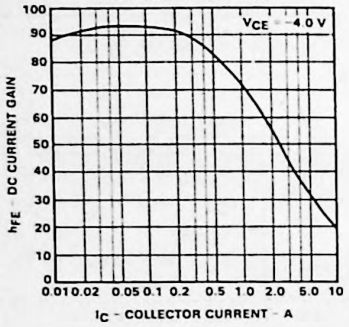
SYMBOL	CHARACTERISTIC	2N5871		2N5872		UNIT	TEST CONDITIONS
		MIN	MAX	MIN	MAX		
OFF CHARACTERISTICS							
$V_{CEO(sus)}$	Collector-Emitter Sustaining Voltage (Note 1)	−60		−80		V	I_C = 100 mA, I_B = 0
I_{CEO}	Collector Cutoff Current		0.5			mA	V_{CE} = −30 V, I_B = 0
					0.5	mA	V_{CE} = −40 V, I_B = 0
I_{CEX}	Collector Cutoff Current		0.25			mA	V_{CE} = −60 V, V_{BE} = 1.5 V
					0.25	mA	V_{CE} = −80 V, V_{BE} = 1.5 V
			2.0			mA	V_{CE} = −60 V, V_{BE} = 1.5 V, T_C = 150°C
					2.0	mA	V_{CE} = −80 V, V_{BE} = 1.5 V, T_C = 150°C
I_{CBO}	Collector Cutoff Current		0.25			mA	V_{CB} = −60 V, I_E = 0
					0.25	mA	V_{CB} = −80 V, I_E = 0
I_{EBO}	Emitter Cutoff Current		1.0		1.0	mA	V_{EB} = −5.0 V, I_C = 0
ON CHARACTERISTICS							
h_{FE}	DC Current Gain (Note 1)	35		35			I_C = 0.5 A, V_{CE} = −4.0 V
		20	100	20	100		I_C = 2.5 A, V_{CE} = −4.0 V
		4.0		4.0			I_C = 7.0 A, V_{CE} = −4.0 V
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage (Note 1)		−1.0		−1.0	V	I_C = 4.0 A, I_B = 0.4 A
			−2.0		−2.0	V	I_C = 7.0 A, I_B = 1.75 A
$V_{BE(sat)}$	Base-Emitter Saturation Voltage (Note 1)		−2.5		−2.5	V	I_C = 7.0 A, I_B = 1.75 A
$V_{BE(on)}$	Base-Emitter "On" Voltage (Note 1)		−1.5		−1.5	V	I_C = 2.5 A, V_{CE} = −4.0 V
DYNAMIC CHARACTERISTICS							
f_T	Current-Gain-Bandwidth Product	4.0		4.0		MHz	I_C = 0.25 A, V_{CE} = −10 V, f = 1.0 MHz
C_{ob}	Output Capacitance		300		200	pF	V_{CB} = −10 V, I_E = 0, f = −1.0 MHz
h_{fe}	Small Signal Current Gain	20		20			I_C = 0.5 A, V_{CE} = −4.0 V, f = 1.0 kHz
SWITCHING CHARACTERISTICS							
RESISTIVE LOAD							
t_r	Rise Time		0.7		0.7	μs	V_{CC} = −30 V, I_C = 2.5 A, I_{B1} = 0.25 A, Duty Cycle = 1.0%
t_s	Storage Time		1.0		1.0	μs	V_{CC} = −30 V, I_C = 2.5 A
t_f	Fall Time		0.8		0.8	μs	I_{B1} = I_{B2} = 0.25 A, Duty Cycle = 1.0%

NOTE: 1. Pulse conditions: Length = 300 μs, Duty Cycle = 2%.

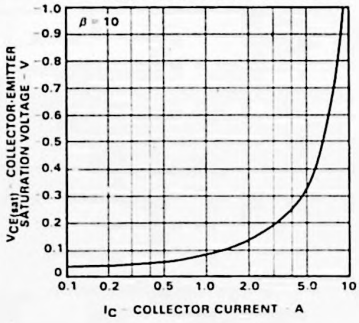
6

TYPICAL ELECTRICAL CHARACTERISTICS

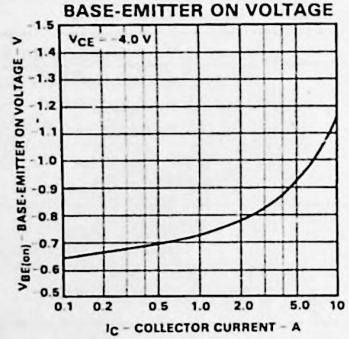
DC CURRENT GAIN



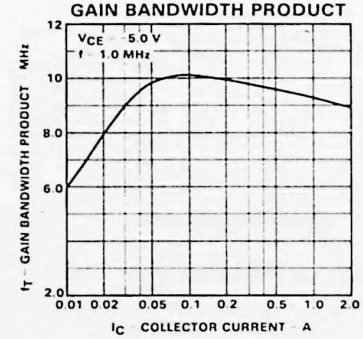
COLLECTOR-EMITTER SATURATION VOLTAGE



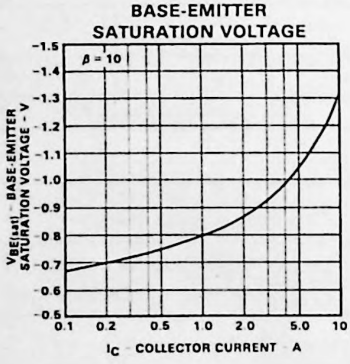
BASE-EMITTER ON VOLTAGE



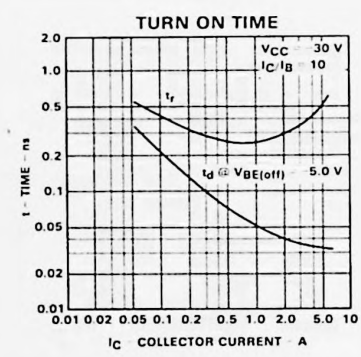
GAIN BANDWIDTH PRODUCT



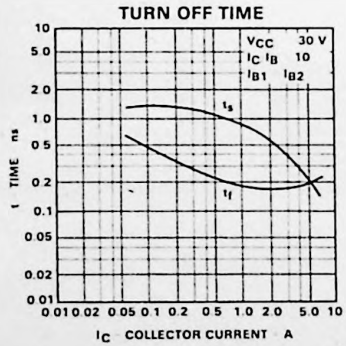
BASE-EMITTER SATURATION VOLTAGE



TURN ON TIME



TURN OFF TIME



POWER TRANSISTOR

NPN SILICON

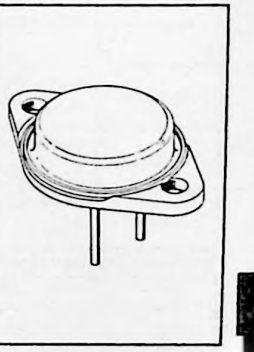
2N5873
2N5874

DESIGNED FOR GENERAL PURPOSE POWER AMPLIFIER AND SWITCHING APPLICATIONS

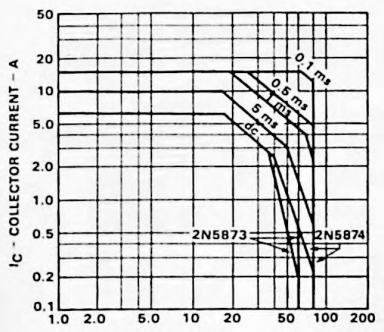
- 115 W DISSIPATION AT 25°C CASE
- 7 A MAXIMUM CONTINUOUS COLLECTOR CURRENT
- 4 MHz f_T AT 0.25 mAdc COLLECTOR CURRENT
- COMPLEMENT TO 2N5871, 2N5872

ABSOLUTE MAXIMUM RATINGS (Note 1)

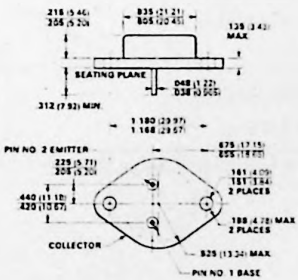
		2N5873	2N5874
Maximum Voltages and Currents			
V_{CEO}	Collector to Emitter Voltage	60 V	80 V
V_{CBO}	Collector to Base Voltage	60 V	80 V
V_{EBO}	Emitter to Base Voltage	5.0 V	5.0 V
I_C	Continuous Collector Current	7.0 A	7.0 A
I_C	Peak Collector Current	15 A	15 A
I_B	Continuous Base Current	2.0 A	2.0 A
Maximum Power Dissipation			
P_D	Total Dissipation @ 25°C Case Temperature		115 W
	Derate Linearly from 25°C		0.66 W/°C
Maximum Temperatures			
T_J, T_{stg}	Storage and Operation Junction Temperatures		−65°C to +200°C
Thermal Characteristics			
$R_{\theta JC}$	Thermal Resistance, Junction to Case		1.52°C/W



SAFE OPERATING AREA



JEDEC (TO-3) Outline



NOTES:
All dimensions in inches (bold) and millimeters (parentheses)
Pins are gold-plated or solder-dipped alloy 52
Pins 1 and 2 electrically isolated from case
Case is third electrical connection
Aluminum package with copper slug, pins are soldered in
Package weight is 7.4 grams
Aluminum cap

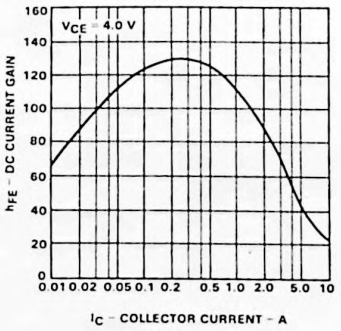
ELECTRICAL CHARACTERISTICS (25°C Case Temperature unless otherwise noted)

SYMBOL	CHARACTERISTIC	2N5873		2N5874		UNIT	TEST CONDITIONS
		MIN	MAX	MIN	MAX		
OFF CHARACTERISTICS							
$V_{CEO(sus)}$	Collector-Emitter Sustaining Voltage (Note 1)	60		80		V	I_C = 100 mA, I_B = 0
I_{CEO}	Collector Cutoff Current		0.5			mA	V_{CE} = 30 V, I_B = 0
					0.5	mA	V_{CE} = 40 V, I_B = 0
I_{CEX}	Collector Cutoff Current		0.25			mA	V_{CE} = 60 V, V_{BE} = −1.5 V
					0.25	mA	V_{CE} = 80 V, V_{BE} = −1.5 V
			2.0			mA	V_{CE} = 60 V, V_{BE} = −1.5 V, T_C = 150°C
					2.0	mA	V_{CE} = 80 V, V_{BE} = −1.5 V T_C = 150°C
I_{CBO}	Collector Cutoff Current		0.25			mA	V_{CB} = 60 V, I_E = 0
					0.25	mA	V_{CB} = 80 V, I_E = 0
I_{EBO}	Emitter Cutoff Current		1.0		1.0	mA	V_{EB} = 5.0 V, I_C = 0
ON CHARACTERISTICS							
h_{FE}	DC Current Gain (Note 1)	35		35			I_C = 0.5 A, V_{CE} = 4.0 V
		20	100	20	100		I_C = 2.5 A, V_{CE} = 4.0 V
		4.0		4.0			I_C = 7.0 A, V_{CE} = 4.0 V
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage (Note 1)		1.0		1.0	V	I_C = 4.0 A, I_B = 0.4 A
			2.0		2.0	V	I_C = 7.0 A, I_B = 1.75 A
$V_{BE(sat)}$	Base-Emitter Saturation Voltage (Note 1)		2.5		2.5	V	I_C = 7.0 A, I_B = 1.75 A
$V_{BE(on)}$	Base-Emitter "On" Voltage (Note 1)		1.5		1.5	V	I_C = 2.5 A, V_{CE} = 4.0 V
DYNAMIC CHARACTERISTICS							
f_T	Current-Gain-Bandwidth Product	4.0		4.0		MHz	I_C = 0.25 A, V_{CE} = 10 V, f = 1.0 MHz
C_{ob}	Output Capacitance		300		200	pF	V_{CB} = 10 V, I_E = 0, f = 1.0 MHz
h_{fe}	Small Signal Current Gain	20		20			I_C = 0.5 A, V_{CE} = 4.0 V, f = 1.0 kHz
SWITCHING CHARACTERISTICS							
t_r	Rise Time		0.7		0.7	μs	V_{CC} = 30 V, I_C = 2.5 A, I_{B1} = 0.25 A, Duty Cycle = 1.0%
t_s	Storage Time		1.0		1.0	μs	V_{CC} = 30 V, I_C = 2.5 A, I_{B1} = I_{B2} = 0.25 A, Duty Cycle = 1.0%
t_f	Fall Time		0.8		0.8	μs	

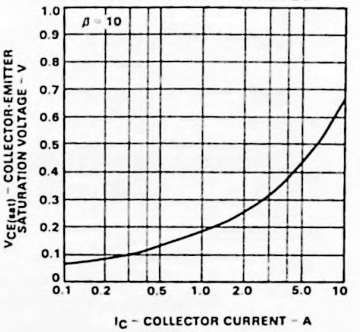
NOTE 1: Pulse conditions: Length = 300 μs, Duty Cycle = 2%.

TYPICAL ELECTRICAL CHARACTERISTICS

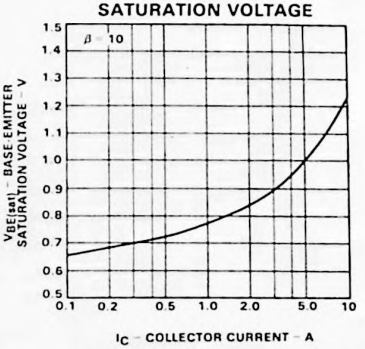
DC CURRENT GAIN



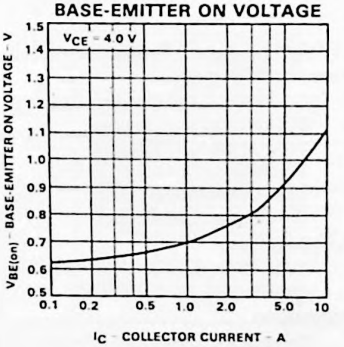
COLLECTOR-EMITTER SATURATION VOLTAGE



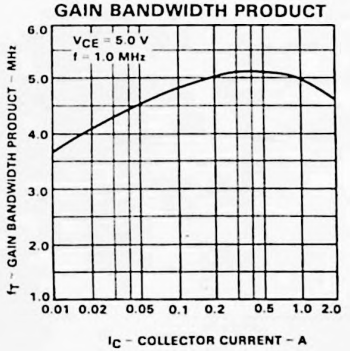
BASE-EMITTER SATURATION VOLTAGE



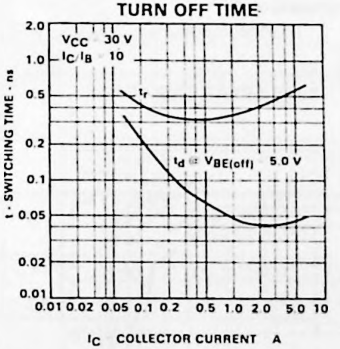
BASE-EMITTER ON VOLTAGE



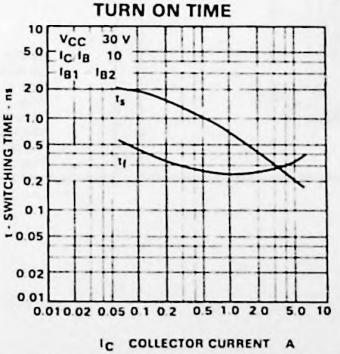
GAIN BANDWIDTH PRODUCT



TURN OFF TIME



TURN ON TIME



POWER TRANSISTOR

PNP SILICON

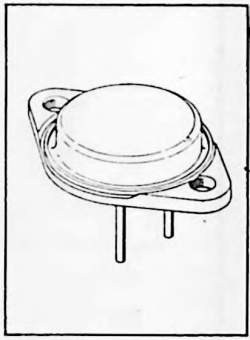
2N5875
2N5876

DESIGNED FOR GENERAL PURPOSE POWER AMPLIFIER AND SWITCHING APPLICATIONS

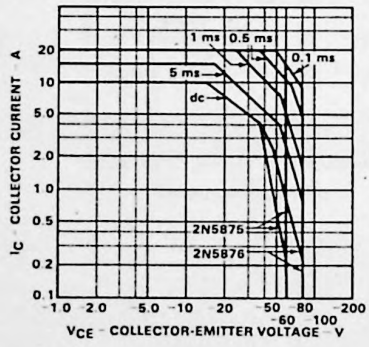
- 150 W DISSIPATION AT 25°C CASE
- 10 A MAXIMUM CONTINUOUS COLLECTOR CURRENT
- 0.5 mAdc I_{CEX} AT RATED VOLTAGE
- 4.0 MHz MINIMUM f_T AT 0.5 A
- COMPLEMENT TO 2N5877, 2N5878

ABSOLUTE MAXIMUM RATINGS (Note 1)

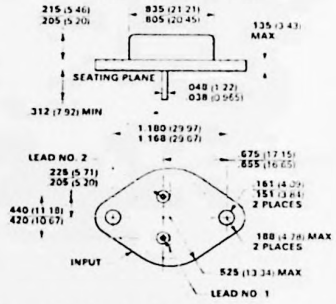
		2N5875	2N5876
Maximum Voltages and Currents			
V_{CEO}	Collector to Emitter Voltage	−60 V	−80 V
V_{CBO}	Collector to Base Voltage	−60 V	−80 V
V_{EBO}	Emitter to Base Voltage	−5.0 V	−5.0 V
I_C	Continuous Collector Current	10 A	10 A
I_C	Peak Collector Current	20 A	20 A
I_B	Continuous Base Current	4.0 A	4.0 A
Maximum Power Dissipation			
P_D	Total Dissipation @ 25°C Case Temperature		150 W
	Derate Linearly from 25°C		0.88 W/°C
Maximum Temperatures			
T_J, T_{stg}	Storage and Operation Junction Temperatures		−65°C to +200°C
Thermal Characteristics			
$R_{\theta JC}$	Thermal Resistance, Junction to Case		1.17°C/W



SAFE OPERATING AREA



JEDEC (TO-3) Outline



NOTES:
All dimensions in inches (bold) and millimeters (parentheses)
Pins are gold-plated or solder-dipped alloy 52
Pins 1 and 2 electrically isolated from case
Case is third electrical connection
Aluminum package with copper slug, pins are soldered in
Package weight is 7.4 grams
Aluminum cap

ELECTRICAL CHARACTERISTICS (25°C Case Temperature unless otherwise noted)

SYMBOL	CHARACTERISTIC	2N5875		2N5876		UNIT	TEST CONDITIONS
		MIN	MAX	MIN	MAX		
OFF CHARACTERISTICS							
$V_{CEO(sus)}$	Collector-Emitter Sustaining Voltage (Note 1)	−60		−80		V	I_C = 200 mA, I_B = 0
I_{CEO}	Collector Cutoff Current		1.0			mA	V_{CE} = −30 V, I_B = 0
					1.0	mA	V_{CE} = −40 V, I_B = 0
I_{CEX}	Collector Cutoff Current		0.5			mA	V_{CE} = −60 V, V_{BE} = 1.5 V
					0.5	mA	V_{CE} = −80 V, V_{BE} = 1.5 V
			5.0			mA	V_{CE} = −60 V, V_{BE} = 1.5 V, T_C = 150°C
					5.0	mA	V_{CE} = −80 V, V_{BE} = 1.5 V, T_C = 150°C
I_{CBO}	Collector Cutoff Current		0.5			mA	V_{CB} = −60 V, I_E = 0
					0.5	mA	V_{CB} = −80 V, I_E = 0
I_{EBO}	Emitter Cutoff Current		1.0		1.0	mA	V_{EB} = −5.0 V, I_C = 0
ON CHARACTERISTICS							
h_{FE}	DC Current Gain (Note 1)	35		35			I_C = 1.0 A, V_{CE} = −4.0 V
		20	100	20	100		I_C = 4.0 A, V_{CE} = −4.0 V
		4.0		4.0			I_C = 10 A, V_{CE} = −4.0 V
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage (Note 1)		−1.0		−1.0	V	I_C = 5.0 A, I_B = 0.5 A
			−3.0		−3.0	V	I_C = 10 A, I_B = 2.5 A
$V_{BE(sat)}$	Base-Emitter Saturation Voltage (Note 1)		−2.5			V	I_C = 10 A, I_B = 2.5 A
$V_{BE(on)}$	Base-Emitter "On" Voltage (Note 1)		−1.5		−1.5	V	I_C = 4.0 A, V_{CE} = −4.0 V
DYNAMIC CHARACTERISTICS							
f_T	Current-Gain-Bandwidth Product	4.0		4.0		MHz	I_C = 0.5 A, V_{CE} = −10 V, f = 1.0 MHz
C_{ob}	Output Capacitance		500		300	pF	V_{CB} = −10 V, I_E = 0, f = 1.0 MHz
h_{fe}	Small Signal Current Gain	20		20			I_C = 1.0 A, V_{CE} = −4.0 V, f = 1.0 kHz
SWITCHING CHARACTERISTICS							
RESISTIVE LOAD							
t_r	Rise Time		0.7		0.7	μs	V_{CC} = −30 V, I_C = 4.0 A, I_{B1} = 0.4 A,
t_s	Storage Time		1.0		1.0	μs	V_{CC} = −30 V, I_C = 4.0 A,
t_f	Fall Time		0.8		0.8	μs	I_{B1} = I_{B2} = 0.4 A, Duty Cycle = 1.0%

NOTE: 1. Pulse conditions: Length = 300 μs, Duty Cycle = 2%.

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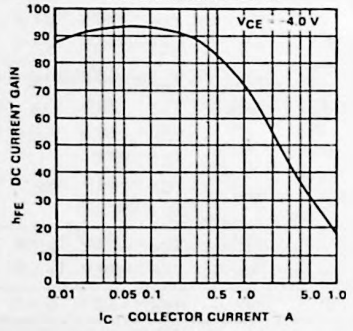
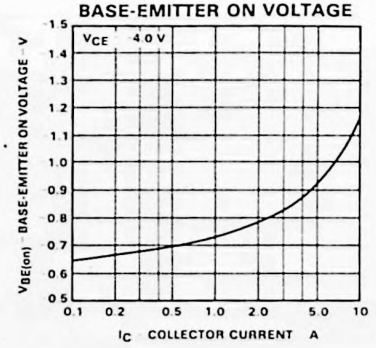
TYPICAL ELECTRICAL CHARACTERISTICS

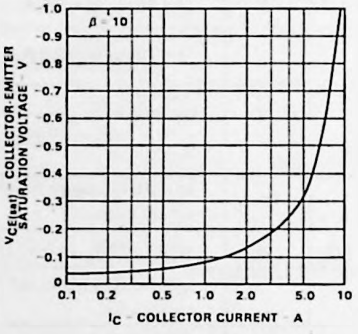
DC CURRENT GAIN



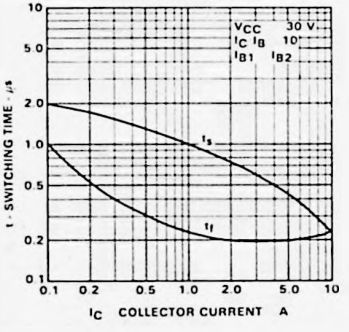
BASE-EMITTER ON VOLTAGE



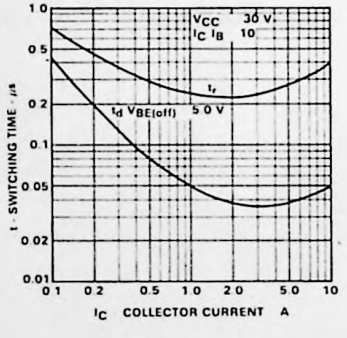
COLLECTOR-EMITTER SATURATION VOLTAGE



TURN-OFF TIME



TURN-ON TIME



POWER TRANSISTOR

NPN SILICON

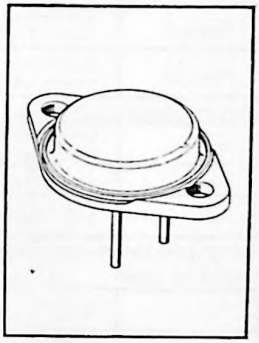
2N5877
2N5878

DESIGNED FOR GENERAL PURPOSE AMPLIFIER AND LOW SPEED SWITCHING APPLICATIONS

- 150 W DISSIPATION AT 25°C CASE
- 10 A MAXIMUM CONTINUOUS COLLECTOR CURRENT
- 0.5 mAdc I_{CEX} AT RATED VOLTAGE
- 4.0 MHz MINIMUM f_T at 0.5 A
- COMPLEMENT TO 2N5875, 2N5876

ABSOLUTE MAXIMUM RATINGS (Note 1)

		2N5877	2N5878
Maximum Voltages and Currents			
V_{CEO}	Collector to Emitter Voltage	60 V	80 V
V_{CBO}	Collector to Base Voltage	60 V	80 V
V_{EBO}	Emitter to Base Voltage	5.0 V	5.0 V
I_C	Continuous Collector Current	10 A	10 A
I_C	Peak Collector Current	20 A	20 A
I_B	Continuous Base Current	4.0 A	4.0 A
Maximum Power Dissipation			
P_D	Total Dissipation @ 25°C Case Temperature		150 W
	Derate Linearly from 25°C		0.88 W/°C
Maximum Temperatures			
T_J, T_{stg}	Storage and Operation Junction Temperatures		−65°C to +200°C
Thermal Characteristics			
$R_{\theta JC}$	Thermal Resistance, Junction to Case		1.17°C/W



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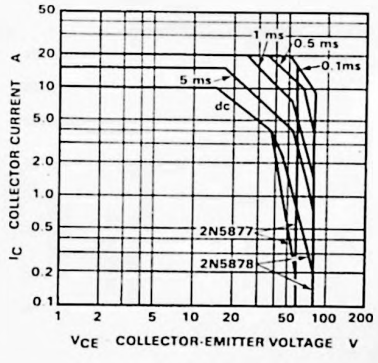
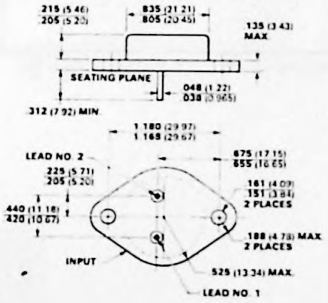
SAFE OPERATING AREA



JEDEC (TO-3) Outline



NOTES:
All dimensions in inches (bold) and millimeters (parentheses)
Pins are gold-plated or solder-dipped alloy 52
Pins 1 and 2 electrically isolated from case
Case is third electrical connection
Aluminum package with copper slug, pins are soldered in
Package weight is 7.4 grams
Aluminum cap

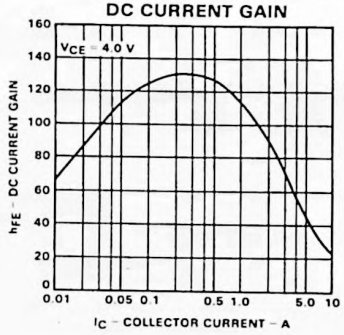
ELECTRICAL CHARACTERISTICS (25°C Case Temperature unless otherwise noted)

SYMBOL	CHARACTERISTIC	2N5877		2N5878		UNIT	TEST CONDITIONS
		MIN	MAX	MIN	MAX		
OFF CHARACTERISTICS							
$V_{CEO(sus)}$	Collector Emitter Sustaining Voltage (Note 1)	60		80		V	I_C = 200 mA, I_B = 0
I_{CEO}	Collector Cutoff Current		1.0			mA	V_{CE} = 30 V, I_B = 0
					1.0	mA	V_{CE} = 40 V, I_B = 0
I_{CEX}	Collector Cutoff Current		0.5			mA	V_{CE} = 60 V, V_{BE} = −1.5 V
					0.5	mA	V_{CE} = 80 V, V_{BE} = −1.5 V
			5.0			mA	V_{CE} = 60 V, V_{BE} = −1.5 V, T_C = 150°C
					5.0	mA	V_{CE} = 80 V, V_{BE} = −1.5 V, T_C = 150°C
I_{CBO}	Collector Cutoff Current		0.5			mA	V_{CB} = 60 V, I_E = 0
					0.5	mA	V_{CB} = 80 V, I_E = 0
I_{EBO}	Emitter Cutoff Current		1.0		1.0	mA	V_{EB} = 5.0 V, I_C = 0
ON CHARACTERISTICS							
h_{FE}	DC Current Gain (Note 1)	35		35			I_C = 1.0 A, V_{CE} = 4.0 V
		20	100	20	100		I_C = 4.0 A, V_{CE} = 4.0 V
		4.0		4.0			I_C = 10 A, V_{CE} = 4.0 V
$V_{CE(sat)}$	Collector Emitter Saturation Voltage (Note 1)		1.0		1.0	V	I_C = 5.0 A, I_B = 0.5 A
			3.0		3.0	V	I_C = 10 A, I_B = 2.5 A
$V_{BE(sat)}$	Base Emitter Saturation Voltage (Note 1)		2.5			V	I_C = 10 A, I_B = 2.5 A
$V_{BE(on)}$	Base Emitter "On" Voltage (Note 1)		1.5		1.5	V	I_C = 4.0 A, V_{CE} = 4.0 V
DYNAMIC CHARACTERISTICS							
f_T	Current Gain Bandwidth Product	4.0		4.0		MHz	I_C = 0.5 A, V_{CE} = 10 V, f = 1.0 MHz
C_{ob}	Output Capacitance		500		300	pF	V_{CB} = 10 V, I_E = 0, f = 1.0 MHz
h_{fe}	Small Signal Current Gain	20		20			I_C = 1.0 A, V_{CE} = 4.0 V, f = 1.0 kHz
SWITCHING CHARACTERISTICS							
RESISTIVE LOAD							
t_r	Rise Time		0.7		0.7	μs	V_{CC} = 30 V, I_C = 4.0 A, I_{B1} = 0.4 A
t_s	Storage Time		1.0		1.0	μs	V_{CC} = 30 V, I_C = 4.0 A, I_{B1} = I_{B2} = 0.4 A, Duty Cycle 1.0%
t_f	Fall Time		0.8		0.8	μs	V_{CC} = 30 V, I_C = 4.0 A I_{B1} = I_{B2} = 0.4 A Duty Cycle 1.0%

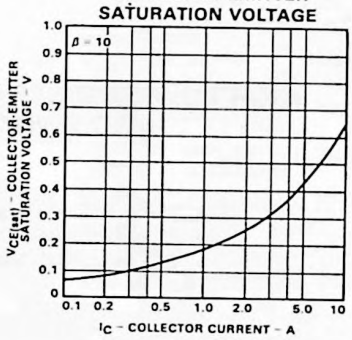
NOTE: 1. Pulse conditions: Length = 300 μs, Duty Cycle = 2%.

TYPICAL ELECTRICAL CHARACTERISTICS

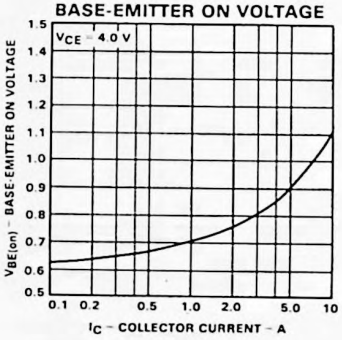
DC CURRENT GAIN



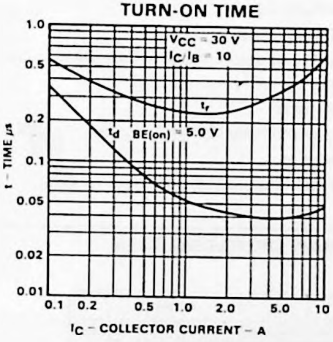
COLLECTOR-EMITTER SATURATION VOLTAGE



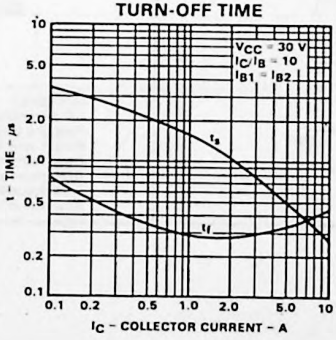
BASE-EMITTER ON VOLTAGE



TURN-ON TIME



TURN-OFF TIME



POWER TRANSISTOR

PNP SILICON

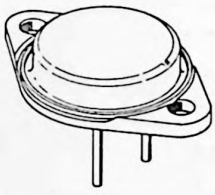
2N5879
2N5880

HIGH POWER GENERAL PURPOSE POWER-AMPLIFIER AND SWITCHING APPLICATIONS

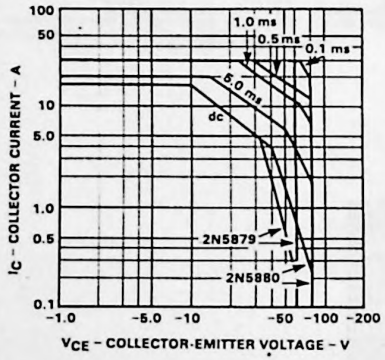
- 160 W DISSIPATION AT 25°C CASE
- 15 A MAXIMUM CONTINUOUS COLLECTOR CURRENT
- COMPLEMENT 2N5881, 2N5882

ABSOLUTE MAXIMUM RATINGS (Note 1)

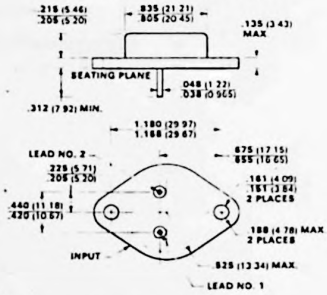
		2N5879	2N5880
Maximum Voltages and Currents			
V_{CEO}	Collector to Emitter Voltage	-60 V	-80 V
V_{CBO}	Collector to Base Voltage	-60 V	-80 V
V_{EBO}	Emitter to Base Voltage	-5.0 V	-5.0 V
I_C	Continuous Collector Current	15 A	15 A
I_C	Peak Collector Current	30 A	30 A
I_B	Continuous Base Current	5.0 A	5.0 A
Maximum Power Dissipation			
P_D	Total Dissipation @ 25°C Case Temperature		160 W
	Derate Linearly from 25°C		0.92 W/°C
Maximum Temperatures			
T_J, T_{stg}	Storage and Operation Junction Temperatures		-65°C to +200°C
Thermal Characteristics			
$R_{\theta JC}$	Thermal Resistance, Junction to Case		1.09°C/W



SAFE OPERATING AREA



JEDEC (TO-3) Outline



NOTES:
All dimensions in inches (bold) and millimeters (parentheses)
Pins are gold-plated or solder-dipped alloy 52
Pins 1 and 2 electrically isolated from case
Case is third electrical connection
Aluminum package with copper slug, pins are soldered in
Package weight is 7.4 grams
Aluminum cap

ELECTRICAL CHARACTERISTICS (25°C Case Temperature unless otherwise noted)

SYMBOL	CHARACTERISTIC	2N5879		2N5880		UNIT	TEST CONDITIONS
		MIN	MAX	MIN	MAX		
OFF CHARACTERISTICS							
$V_{CEO(sus)}$	Collector-Emitter Sustaining Voltage (Note 1)	−60		−80		V	I_C = 200 mA, I_B = 0
I_{CEO}	Collector Cutoff Current		1.0			mA	V_{CE} = −30 V, I_B = 0
					1.0	mA	V_{CE} = −40 V, I_B = 0
I_{CEX}	Collector Cutoff Current		0.5			mA	V_{CE} = −60 V, V_{BE} = 1.5 V
					0.5	mA	V_{CE} = −80 V, V_{BE} = 1.5 V
			5.0			mA	V_{CE} = −60 V, V_{BE} = 1.5 V, T_C = 150°C
					5.0	mA	V_{CE} = −80 V, V_{BE} = 1.5 V, T_C = 150°C
I_{CBO}	Collector Cutoff Current		0.5			mA	V_{CB} = −60 V, I_E = 0
					0.5	mA	V_{CB} = −80 V, I_E = 0
I_{EBO}	Emitter Cutoff Current		1.0		1.0	mA	V_{EB} = −5.0 V, I_C = 0
ON CHARACTERISTICS							
h_{FE}	DC Current Gain (Note 1)	4.0		4.0			I_C = 15 A, V_{CE} = −4.0 V
		20	100	20	100		I_C = 6.0 A, V_{CE} = −4.0 V
		35		35			I_C = 2.0 A, V_{CE} = −4.0 V
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage (Note 1)		−1.0		−1.0	V	I_C = 7.0 A, I_B = 0.7 A
			−4.0		−4.0	V	I_C = 15 A, I_B = 3.75 A
$V_{BE(sat)}$	Base-Emitter Saturation Voltage (Note 1)		−2.5		−2.5	V	I_C = 15 A, I_B = 3.75 A
$V_{BE(on)}$	Base-Emitter "On" Voltage (Note 1)		−1.5		−1.5	V	I_C = 6.0 A, V_{CE} = −4.0 V
DYNAMIC CHARACTERISTICS							
f_T	Current-Gain-Bandwidth Product	4.0		4.0		MHz	I_C = 1.0 A, V_{CE} = −1.0 V, f = 1.0 MHz
C_{ob}	Output Capacitance		600		600	pF	V_{CB} = −10 V, I_E = 0, f = 0.1 MHz
h_{fe}	Small Signal Current Gain	20		20			I_C = 2.0 A, V_{CE} = −4.0 V, f = 1.0 kHz
SWITCHING CHARACTERISTICS							
RESISTIVE LOAD							
t_r	Rise Time		0.7		0.7	μs	V_{CC} = −30 V, I_C = 6.0 A, I_{B1} = 0.6 A, t_p = 25 μs, Duty Cycle 1%
t_s	Storage Time		1.0		1.0	μs	V_{CC} = −30 V, I_C = 6.0 A, I_{B1} = I_{B2} = 0.6 A, t_p = 25 μs, Duty Cycle 1%
t_f	Fall Time		0.8		0.8	μs	

NOTE: 1. Pulse conditions: Length = 300 μs, Duty Cycle = 2%.

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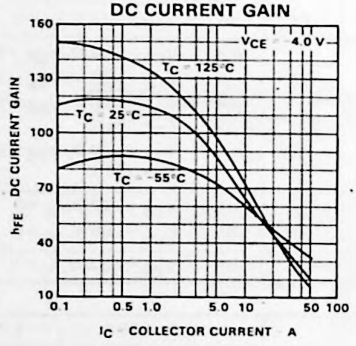
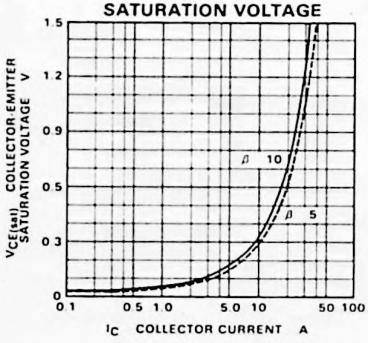
TYPICAL ELECTRICAL CHARACTERISTICS

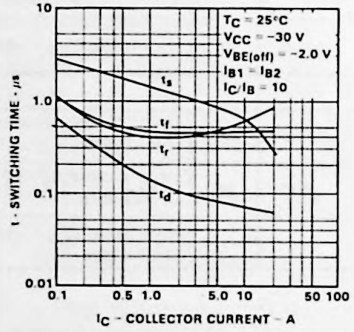
DC CURRENT GAIN



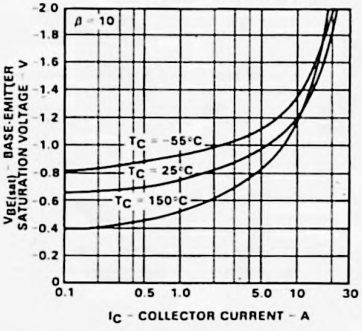
COLLECTOR-EMITTER SATURATION VOLTAGE



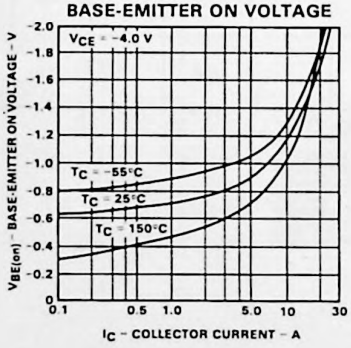
SWITCHING TIME



BASE-EMITTER SATURATION VOLTAGE



BASE-EMITTER ON VOLTAGE



POWER TRANSISTOR

NPN SILICON

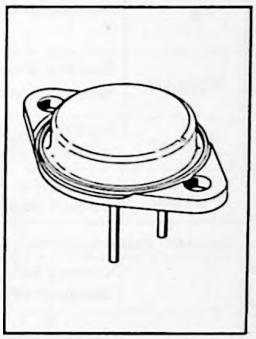
2N5881
2N5882

HIGH POWER GENERAL PURPOSE POWER-AMPLIFIER AND SWITCHING APPLICATIONS

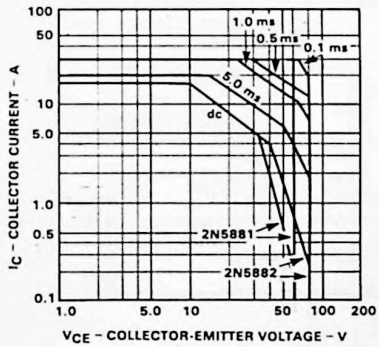
- 160 W DISSIPATION AT 25°C CASE
- 15 A MAXIMUM CONTINUOUS COLLECTOR CURRENT
- COMPLEMENT 2N5879, 2N5880

ABSOLUTE MAXIMUM RATINGS (Note 1)

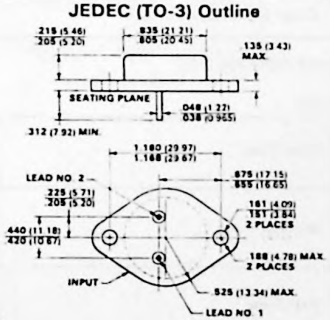
		2N5881	2N5882
Maximum Voltages and Currents			
V_{CEO}	Collector to Emitter Voltage	60 V	80 V
V_{CBO}	Collector to Base Voltage	60 V	80 V
V_{EBO}	Emitter to Base Voltage	5.0 V	5.0 V
I_C	Continuous Collector Current	15 A	15 A
I_C	Peak Collector Current	30 A	30 A
I_B	Continuous Base Current	5.0 A	5.0 A
Maximum Power Dissipation			
P_D	Total Dissipation @ 25°C Case Temperature		160 W
	Derate Linearly from 25°C		0.92 W/°C
Maximum Temperatures			
T_J, T_{stg}	Storage and Operation Junction Temperatures		−65°C to +200°C
Thermal Characteristics			
$R_{\theta JC}$	Thermal Resistance, Junction to Case		1.09°C/W



SAFE OPERATING AREA



JEDEC (TO-3) Outline



NOTES:
All dimensions in inches (bold) and millimeters (parentheses)
Pins are gold-plated or solder-dipped alloy 52
Pins 1 and 2 electrically isolated from case
Case is third electrical connection
Aluminum package with copper slug, pins are soldered in
Package weight is 7.4 grams
Aluminum cap

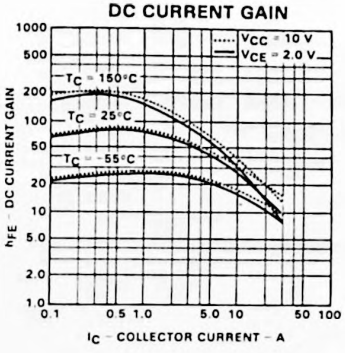
ELECTRICAL CHARACTERISTICS (25°C Case Temperature unless otherwise noted)

SYMBOL	CHARACTERISTIC	2N5881		2N5882		UNIT	TEST CONDITIONS
		MIN	MAX	MIN	MAX		
OFF CHARACTERISTICS							
$V_{CEO(sus)}$	Collector Emitter Sustaining Voltage (Note 1)	60		80		V	I_C = 200 mA, I_B = 0
I_{CEO}	Collector Cutoff Current		1.0			mA	V_{CE} = 30 V, I_B = 0
					1.0	mA	V_{CE} = 40 V, I_B = 0
I_{CEX}	Collector Cutoff Current		0.5			mA	V_{CE} = 60 V, V_{BE} = −1.5 V
					0.5	mA	V_{CE} = 80 V, V_{BE} = −1.5 V
			5.0			mA	V_{CE} = 60 V, V_{BE} = −1.5 V, T_C = 150°C
					5.0	mA	V_{CE} = 80 V, V_{BE} = −1.5 V, T_C = 150°C
I_{CBO}	Collector Cutoff Current		0.5			mA	V_{CB} = 60 V, I_E = 0
					0.5	mA	V_{CB} = 80 V, I_E = 0
I_{EBO}	Emitter Cutoff Current		1.0		1.0	mA	V_{EB} = 5.0 V, I_C = 0
ON CHARACTERISTICS							
h_{FE}	DC Current Gain (Note 1)	4.0		4.0			I_C = 15 A, V_{CE} = 4.0 V
		20	100	20	100		I_C = 6.0 A, V_{CE} = 4.0 V
		35		35			I_C = 2.0 A, V_{CE} = 4.0 V
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage (Note 1)		1.0		1.0	V	I_C = 7.0 A, I_B = 0.7 A
			4.0		4.0	V	I_C = 15 A, I_B = 3.75 A
$V_{BE(sat)}$	Base-Emitter Saturation Voltage (Note 1)		2.5		2.5	V	I_C = 15 A, I_B = 3.75 A
$V_{BE(on)}$	Base-Emitter "On" Voltage (Note 1)		1.5		1.5	V	I_C = 60 A, V_{CE} = 4.0 V
DYNAMIC CHARACTERISTICS							
f_T	Current-Gain-Bandwidth Product	4.0		4.0		MHz	I_C = 1.0 A, V_{CE} = 10 V, f = 1.0 MHz
C_{ob}	Output Capacitance		400		400	pF	V_{CB} = 10 V, I_E = 0 f = 0.1 MHz
h_{fe}	Small Signal Current Gain	20		20			I_C = 2.0 A, V_{CE} = 4.0 V, f = 1.0 kHz
SWITCHING CHARACTERISTICS							
RESISTIVE LOAD							
t_r	Rise Time		0.7		0.7	μs	V_{CC} = 30 V, I_C = 6.0 A, I_{B1} = 0.6 A, t_p = 25 μs, Duty Cycle 1%
t_s	Storage Time		1.0		1.0	μs	V_{CC} = 30 V, I_C = 6.0 A, I_{B1} = I_{B2} = 0.6 A, t_p = 25 μs, Duty Cycle 1%
t_f	Fall Time		0.8		0.8	μs	

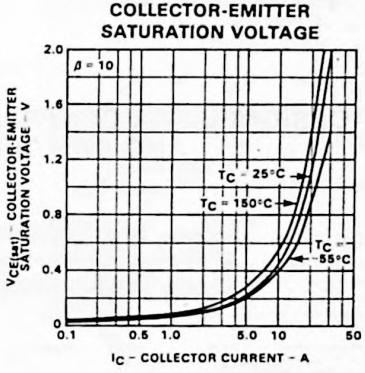
NOTE: 1. Pulse conditions: Length = 300 μs, Duty Cycle = 2%.

TYPICAL ELECTRICAL CHARACTERISTICS

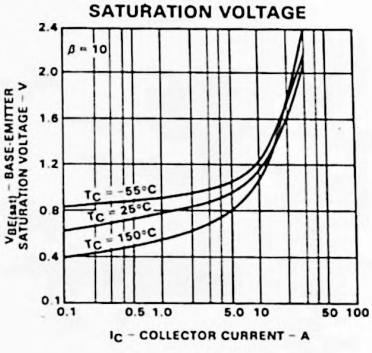
DC CURRENT GAIN



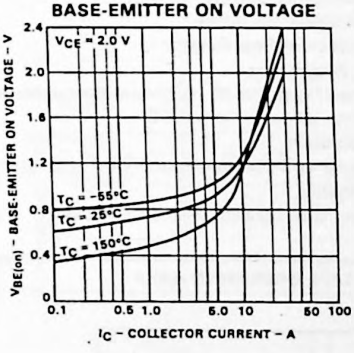
COLLECTOR-EMITTER SATURATION VOLTAGE



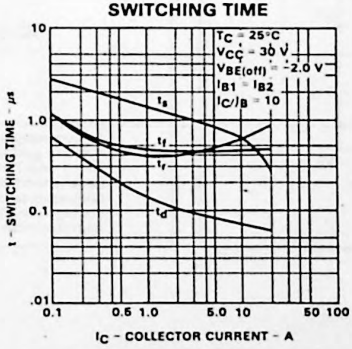
BASE-EMITTER SATURATION VOLTAGE



BASE-EMITTER ON VOLTAGE



SWITCHING TIME



6

POWER TRANSISTOR

PNP SILICON

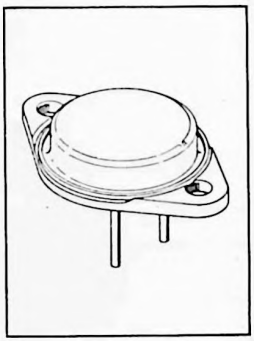
2N5883
2N5884

DESIGNED FOR GENERAL PURPOSE POWER AMPLIFIER AND SWITCHING APPLICATIONS

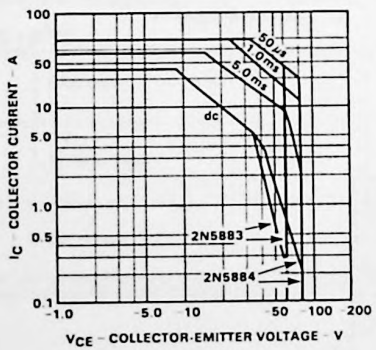
- 200 W DISSIPATION AT 25°C CASE
- 25 A MAXIMUM CONTINUOUS COLLECTOR CURRENT
- COMPLEMENTS 2N5885, 2N5886

ABSOLUTE MAXIMUM RATINGS (Note 1)

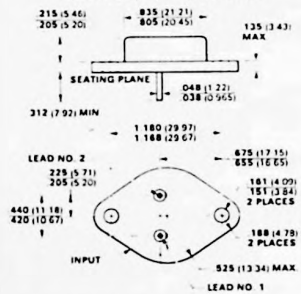
		2N5883	2N5884
Maximum Voltages and Currents			
V_{CEO}	Collector to Emitter Voltage	−60 V	−80 V
V_{CBO}	Collector to Base Voltage	−60 V	−80 V
V_{EBO}	Emitter to Base Voltage	−5.0 V	−5.0 V
I_C	Continuous Collector Current	25 A	25 A
I_C	Peak Collector Current	50 A	50 A
I_B	Continuous Base Current	7.5 A	7.5 A
Maximum Power Dissipation			
P_D	Total Dissipation @ 25°C Case Temperature		200 W
	Derate Linearly from 25°C		1.14 W/°C
Maximum Temperatures			
T_J, T_{stg}	Storage and Operation Junction Temperatures		−65°C to +200°C
Thermal Characteristics			
$R_{\theta JC}$	Thermal Resistance, Junction to Case		0.86°C/W



SAFE OPERATING AREA



JEDEC (TO-3) Outline



NOTES:
All dimensions in inches (bold) and millimeters (parentheses)
Pins are gold-plated or solder-dipped alloy 52
Pins 1 and 2 electrically isolated from case
Case is third electrical connection
Aluminum package with copper slug, pins are soldered in
Package weight is 7.4 grams
Aluminum cap

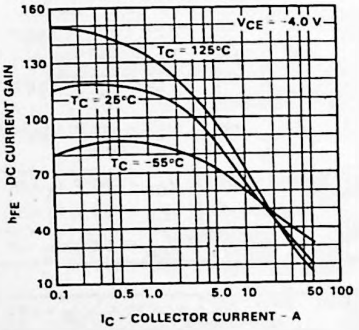
ELECTRICAL CHARACTERISTICS (25°C Case Temperature unless otherwise noted)

SYMBOL	CHARACTERISTIC	2N5883 MIN	2N5883 MAX	2N5884 MIN	2N5884 MAX	UNIT	TEST CONDITIONS
OFF CHARACTERISTICS							
$V_{CEO(sus)}$	Collector-Emitter Sustaining Voltage (Note 1)	−60		−80		V	I_C = 200 mA, I_B = 0
I_{CEO}	Collector Cutoff Current		2.0			mA	V_{CE} = −30 V, I_B = 0
					2.0	mA	V_{CE} = −40 V, I_B = 0
I_{CEX}	Collector Cutoff Current		1.0			mA	V_{CE} = −60 V, V_{BE} = 1.5 V
					1.0	mA	V_{CE} = −80 V, V_{BE} = 1.5 V
			10			mA	V_{CE} = −60 V, V_{BE} = 1.5 V, T_C = 150°C
					10	mA	V_{CE} = −80 V, V_{BE} = 1.5 V, T_C = 150°C
I_{CBO}	Collector Cutoff Current		1.0			mA	V_{CB} = −60 V, I_E = 0
					1.0	mA	V_{CB} = −80 V, I_E = 0
I_{EBO}	Emitter Cutoff Current		1.0		1.0	mA	V_{EB} = −5.0 V, I_C = 0
ON CHARACTERISTICS							
h_{FE}	DC Current Gain (Note 1)	4.0		4.0			I_C = 25 A, V_{CE} = −4.0 V
		20	100	20	100		I_C = 10 A, V_{CE} = −4.0 V
		35		35			I_C = 3.0 A, V_{CE} = −4.0 V
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage (Note 1)		−1.0		−1.0	V	I_C = 15 A, I_B = 1.5 A
			−4.0		−4.0	V	I_C = 25 A, I_B = 6.25 A
$V_{BE(sat)}$	Base-Emitter Saturation Voltage (Note 1)		−2.5		−2.5	V	I_C = 25 A, I_B = 6.25 A
$V_{BE(on)}$	Base-Emitter "On" Voltage (Note 1)		−1.5		−1.5	V	I_C = 10 A, V_{CE} = −4.0 V
DYNAMIC CHARACTERISTICS							
C_{ob}	Output Capacitance		1000		1000	pF	V_{CB} = −10 V, I_E = 0, f = 1.0 MHz
$\|h_{fe}\|$	Magnitude of Common Emitter Small Signal Current Gain	4.0		4.0			I_C = 1.0 A, V_{CE} = −10 V, f = 1.0 MHz
h_{fe}	Small Signal Current Gain	20		20			I_C = 3.0 A, V_{CE} = −4.0 V, f = 1.0 kHz
SWITCHING CHARACTERISTICS							
RESISTIVE LOAD							
t_r	Rise Time		0.7		0.7	μs	V_{CC} = −30 V, I_C = 10 A, I_{B1} = 1.0 A, t_p = 10 to 100 μs, Duty Cycle 2%
t_s	Storage Time		1.0		1.0	μs	V_{CC} = −30 V, I_C = 10 A, I_{B1} = I_{B2} = 1.0 A, t_p = 10 to 100 μs, Duty Cycle 2%
t_f	Fall Time		0.8		0.8	μs	

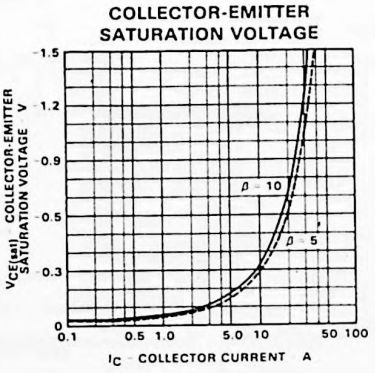
NOTE: 1. Pulse conditions: Length = 300 μs, Duty Cycle = 2%.

TYPICAL ELECTRICAL CHARACTERISTICS

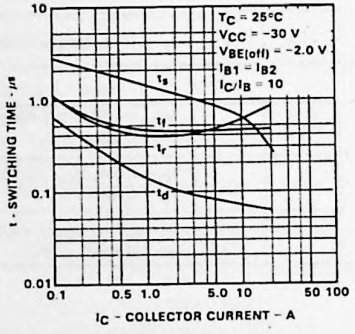
DC CURRENT GAIN



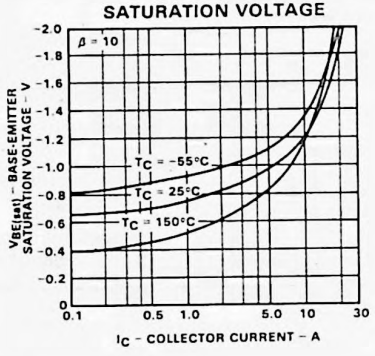
COLLECTOR-EMITTER SATURATION VOLTAGE



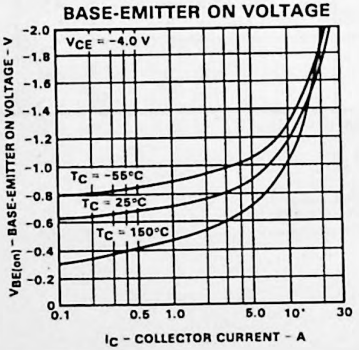
SWITCHING TIME



BASE-EMITTER SATURATION VOLTAGE



BASE-EMITTER ON VOLTAGE



POWER TRANSISTOR

NPN SILICON

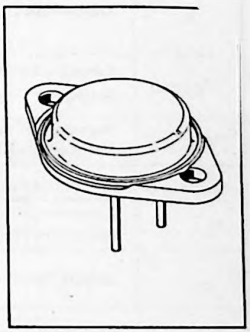
2N5885
2N5886

DESIGNED FOR GENERAL PURPOSE POWER AMPLIFIER AND SWITCHING APPLICATIONS

- 200 W DISSIPATION AT 25°C CASE
- 25 A MAXIMUM CONTINUOUS COLLECTOR CURRENT
- COMPLEMENTS 2N5883, 2N5884

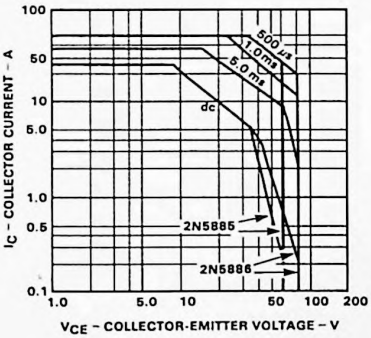
ABSOLUTE MAXIMUM RATINGS (Note 1)

		2N5885	2N5886
Maximum Voltages and Currents			
V_{CEO}	Collector to Emitter Voltage	60 V	80 V
V_{CBO}	Collector to Base Voltage	60 V	80 V
V_{EBO}	Emitter to Base Voltage	5.0 V	5.0 V
I_C	Continuous Collector Current	25 A	25 A
I_C	Peak Collector Current	50 A	50 A
I_B	Continuous Base Current	7.5 A	7.5 A
Maximum Power Dissipation			
P_D	Total Dissipation @ 25°C Case Temperature		200 W
	Derate Linearly from 25°C		1.14 W/°C
Maximum Temperatures			
T_J, T_{stg}	Storage and Operation Junction Temperatures		−65°C to +200°C
Thermal Characteristics			
$R_{\theta JC}$	Thermal Resistance, Junction to Case		0.86°C/W

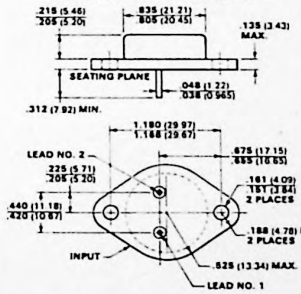


6

SAFE OPERATING AREA



JEDEC (TO-3) Outline



NOTES:
All dimensions in inches (bold) and millimeters (parentheses)
Pins are gold-plated or solder-dipped alloy 52
Pins 1 and 2 electrically isolated from case
Case is third electrical connection
Aluminum package with copper slug, pins are soldered in
Package weight is 7.4 grams
Aluminum cap

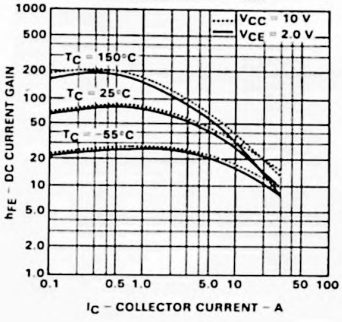
ELECTRICAL CHARACTERISTICS (25°C Case Temperature unless otherwise noted)

SYMBOL	CHARACTERISTIC	2N5885		2N5886		UNIT	TEST CONDITIONS
		MIN	MAX	MIN	MAX		
OFF CHARACTERISTICS							
$V_{CEO(sus)}$	Collector-Emitter Sustaining Voltage (Note 1)	60		80		V	I_C = 200 mA, I_B = 0
I_{CEO}	Collector Cutoff Current		2.0			mA	V_{CE} = 30 V, I_B = 0
					2.0	mA	V_{CE} = 40 V, I_B = 0
I_{CEX}	Collector Cutoff Current		1.0			mA	V_{CE} = 60 V, V_{BE} = −1.5 V
					1.0	mA	V_{CE} = 80 V, V_{BE} = −1.5 V
			10			mA	V_{CE} = 60 V, V_{BE} = −1.5 V, T_C = 150°C
					10	mA	V_{CE} = 80 V, V_{BE} = −1.5 V, T_C = 150°C
I_{CBO}	Collector Cutoff Current		1.0			mA	V_{CB} = 60 V, I_E = 0
					1.0	mA	V_{CB} = 80 V, I_E = 0
I_{EBO}	Emitter Cutoff Current		1.0		1.0	mA	V_{EB} = 5.0 V, I_C = 0
ON CHARACTERISTICS							
h_{FE}	DC Current Gain (Note 1)	4.0		4.0			I_C = 25 A, V_{CE} = 4.0 V
		20	100	20	100		I_C = 10 A, V_{CE} = 4.0 V
		35		35			I_C = 3.0 A, V_{CE} = 4.0 V
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage (Note 1)		1.0		1.0	V	I_C = 15 A, I_B = 1.5 A
			4.0		4.0	V	I_C = 25 A, I_B = 6.25 A
$V_{BE(sat)}$	Base-Emitter Saturation Voltage (Note 1)		2.5		2.5	V	I_C = 25 A, I_B = 6.25 A
DYNAMIC CHARACTERISTICS							
f_T	Current-Gain-Bandwidth Product	4.0		4.0		MHz	I_C = 1.0 A, V_{CE} = 10 V, f = 1.0 MHz
C_{ob}	Output Capacitance		500		500	pF	V_{CB} = 10 V, I_E = 0, f = 1.0 MHz
h_{fe}	Small Signal Current Gain	20		20			I_C = 3.0 A, V_{CE} = 4.0 V, f = 1.0 kHz

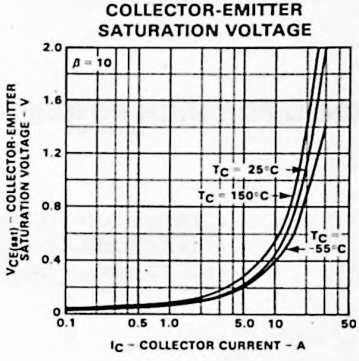
NOTE: 1. Pulse conditions: Length = 300 μs, Duty Cycle = 2%.

TYPICAL ELECTRICAL CHARACTERISTICS

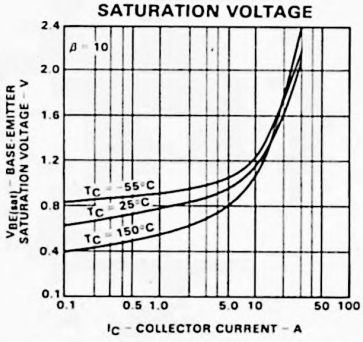
DC CURRENT GAIN



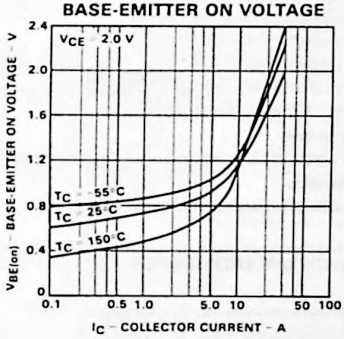
COLLECTOR-EMITTER SATURATION VOLTAGE



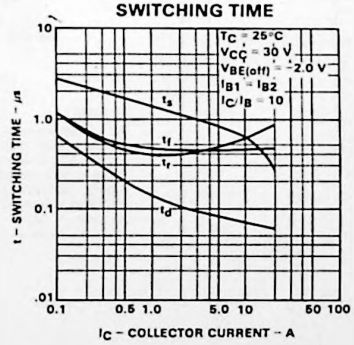
BASE-EMITTER SATURATION VOLTAGE



BASE-EMITTER ON VOLTAGE



SWITCHING TIME



POWER TRANSISTOR

PNP SILICON

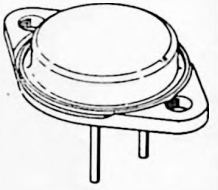
2N6029
2N6030
2N6031

DESIGNED FOR HIGH POWER AUDIO AND SWITCHING REGULATORS

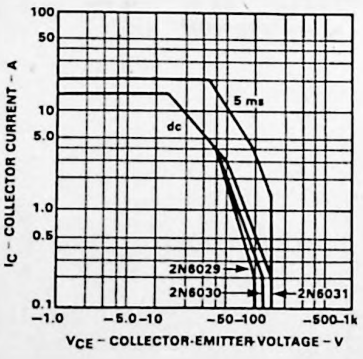
- 200 W DISSIPATION AT 25°C CASE
- 16 A MAXIMUM CONTINUOUS COLLECTOR CURRENT
- 25 TO 100 h_{FE} AT 8 A, −2.0 V 2N6029

ABSOLUTE MAXIMUM RATINGS (Note 1)

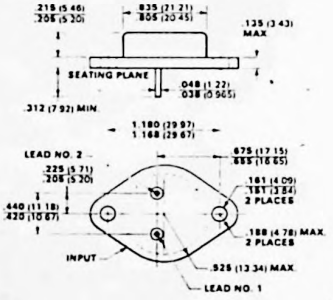
		2N6029	2N6030	2N6031
Maximum Voltages and Currents				
V_{CEO}	Collector to Emitter Voltage	−100 V	−120 V	−140 V
V_{CBO}	Collector to Base Voltage	−100 V	−120 V	−140 V
V_{EBO}	Emitter to Base Voltage	−7.0 V	−7.0 V	−7.0 V
I_C	Continuous Collector Current	16 A	16 A	16 A
I_B	Continuous Base Current	5.0 A	5.0 A	5.0 A
Maximum Power Dissipation				
P_D	Total Dissipation @ 25°C Case Temperature			200 W
	Derate Linearly from 25°C			1.14 W/°C
Maximum Temperatures				
T_J, T_{stg}	Storage and Operation Junction Temperatures			−65°C to +200°C
Thermal Characteristics				
$R_{\theta JC}$	Thermal Resistance, Junction to Case			0.88°C/W



SAFE OPERATING AREA



JEDEC (TO-3) Outline



NOTES:
All dimensions in inches (bold) and millimeters (parentheses)
Pins are gold-plated or solder-dipped alloy 52
Pins 1 and 2 electrically isolated from case
Case is third electrical connection
Aluminum package with copper slug, pins are soldered in
Package weight is 7.4 grams
Aluminum cap

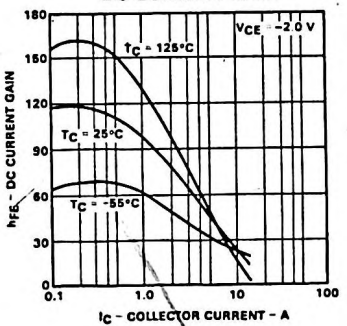
ELECTRICAL CHARACTERISTICS (25°C Case Temperature unless otherwise noted)

SYMBOL	CHARACTERISTIC	2N6029		2N6030		2N6031		UNITS	TEST CONDITIONS
		MIN	MAX	MIN	MAX	MIN	MAX		
OFF CHARACTERISTICS									
$V_{CEO(sus)}$	Collector-Emitter Sustaining Voltage (Note 1)	−100		−120		−140		V	I_C = 200 mA, I_B = 0
I_{CEO}	Collector Cutoff Current		2.0					mA	V_{CE} = −50 V, I_B = 0
					2.0			mA	V_{CE} = −60 V, I_B = 0
							2.0	mA	V_{CE} = −70 V, I_B = 0
I_{CEX}	Collector Cutoff Current		2.0					mA	V_{CE} = −100 V, V_{BE} = 1.5 V
					2.0			mA	V_{CE} = −120 V, V_{BE} = 1.5 V
							2.0	mA	V_{CE} = −140 V, V_{BE} = 1.5 V
			7.0					mA	V_{CE} = −100 V, V_{BE} = 1.5 V, T_C = 150°C
					7.0			mA	V_{CE} = −120 V, V_{BE} = 1.5 V, T_C = 150°C
							7.0	mA	V_{CE} = −140 V, V_{BE} = 1.5 V, T_C = 150°C
I_{CBO}	Collector Cutoff Current		2.0					mA	V_{CB} = −100 V, I_E = 0
					2.0			mA	V_{CB} = −120 V, I_E = 0
							2.0	mA	V_{CB} = −140 V, I_E = 0
I_{EBO}	Emitter Cutoff Current		5.0		5.0		5.0	mA	V_{EB} = −7.0 V, I_C = 0
ON CHARACTERISTICS									
h_{FE}	DC Current Gain (Note 1)	25	100	20	80	15	60		I_C = 8.0 A, V_{CE} = −2.0 V
		4.0		4.0		4.0			I_C = 16.0 A, V_{CE} = −2.0 V
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage (Note 1)		−1.0		−1.0		−1.0	V	I_C = 10 A, I_B = 1.0 A
			−2.0		−2.0		−2.0	V	I_C = 16 A, I_B = 4.0 A
$V_{BE(sat)}$	Base-Emitter Saturation Voltage (Note 1)		−1.8		−1.8		−1.8	V	I_C = 10 A, I_B = 1.0 A
$V_{BE(on)}$	Base-Emitter "On" Voltage (Note 1)		−1.5		−1.5		−1.5	V	I_C = 8.0 A, V_{CE} = −2.0 V
DYNAMIC CHARACTERISTICS									
f_T	Current-Gain-Bandwidth Product	1.0		1.0		1.0		MHz	I_C = 1.0 A, V_{CE} = −20 V, f = 0.5 MHz
C_{ob}	Output Capacitance		1000		1000		1000	pF	V_{CB} = −10 V, I_E = 0, f = 0.1 MHz

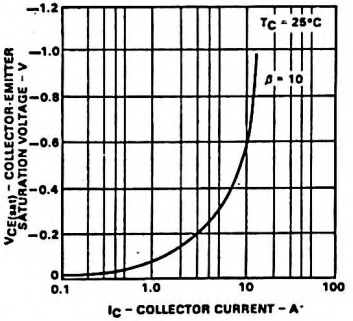
NOTE: 1. Pulse conditions: Length = 300 μs, Duty Cycle = 2%.

TYPICAL ELECTRICAL CHARACTERISTICS

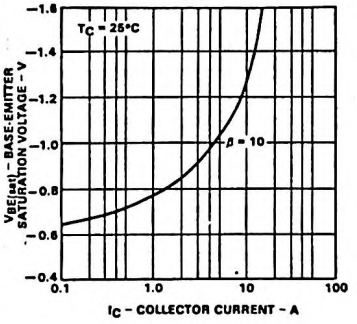
DC CURRENT GAIN



COLLECTOR-EMITTER SATURATION VOLTAGE



BASE-EMITTER SATURATION VOLTAGE



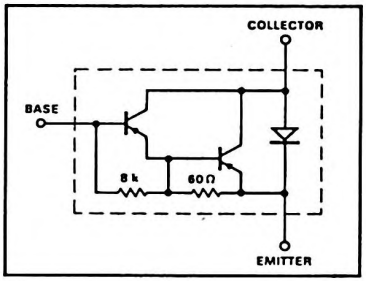
POWER DARLINGTON

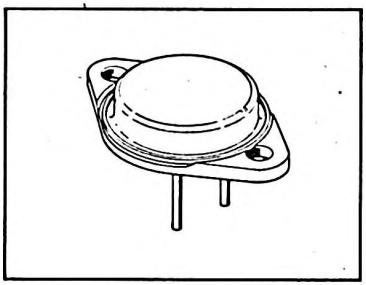
PNP SILICON

2N6050
2N6051
2N6052

DESIGNED FOR GENERAL PURPOSE AMPLIFIER AND LOW SPEED SWITCHING APPLICATIONS

- 150 W DISSIPATION AT 25°C CASE
- 12 A MAXIMUM CONTINUOUS COLLECTOR CURRENT
- h_{FE} TYPICAL OF 2000 AT 3.0 A

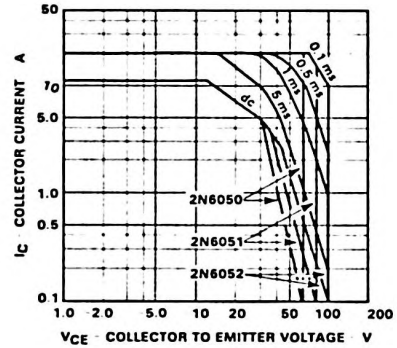




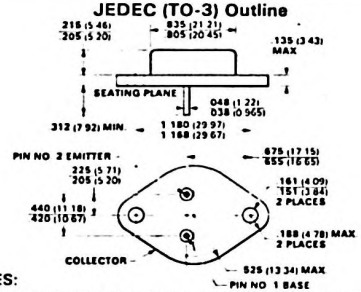
ABSOLUTE MAXIMUM RATINGS

		2N6050	2N6051	2N6052
Maximum Voltages and Currents				
V_{CE}	Collector to Emitter Voltage	−60 V	−80 V	−100 V
V_{CB}	Collector to Base Voltage	−60 V	−80 V	−100 V
V_{EB}	Emitter to Base Voltage	−5.0 V	−5.0 V	−5.0 V
I_C	Continuous Collector Current	12 A	12 A	12 A
I_B	Continuous Base Current	0.2 A	0.2 A	0.2 A
Maximum Power Dissipation				
P_D	Total Dissipation @ 25°C Case Temperature			150 W
	Derate Linearly from 25°C			0.857 W/°C
Maximum Temperatures				
T_J, T_{stg}	Storage and Operation Junction Temperatures			−65°C to +200°C
Thermal Characteristics				
$R_{\theta JC}$	Thermal Resistance, Junction to Case			1.17 °C/W
T_P	Maximum Pin Temperature (Soldering, 10 s)			235°C

SAFE OPERATING AREA



JEDEC (TO-3) Outline



NOTES:
All dimensions in inches (bold) and millimeters (parentheses)
Pins are gold-plated or solder-dipped alloy 52
Pins 1 and 2 electrically isolated from case
Case is third electrical connection
Aluminum package with copper slug, pins are soldered in
Package weight is 7.4 grams
Aluminum cap

ELECTRICAL CHARACTERISTICS (25°C Case Temperature unless otherwise noted)

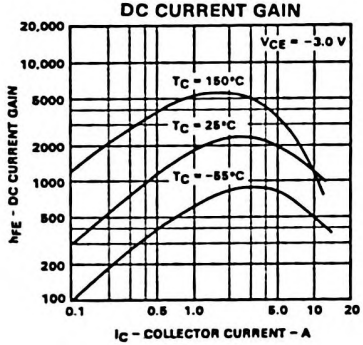
SYMBOL	PARAMETER	2N6050		2N6051		2N6052		UNITS	TEST CONDITIONS
		MIN	MAX	MIN	MAX	MIN	MAX		
OFF CHARACTERISTICS									
$V_{CEO(sus)}$	Collector-Emitter Sustaining Voltage (Note 1)	−60		−80		−100		V	I_C = 100 mA, I_B = 0
I_{CEO}	Collector Cutoff Current		1.0					mA	V_{CE} = −30 V, I_B = 0
					1.0			mA	V_{CE} = −40 V, I_B = 0
							1.0	mA	V_{CE} = −50 V, I_B = 0
I_{EBO}	Emitter Cutoff Current		2.0		2.0		2.0	mA	V_{EB} = −5.0 V, I_C = 0
I_{CEX}	Collector Cutoff Current		0.5					mA	V_{CE} = −60 V, V_{BE} = 1.5 V
					0.5			mA	V_{CE} = −80 V, V_{BE} = 1.5 V
							0.5	mA	V_{CE} = −100 V, V_{BE} = 1.5 V
			5.0					mA	V_{CE} = −60 V, V_{BE} = 1.5 V, T_C = 150°C
					5.0			mA	V_{CE} = −80 V, V_{BE} = 1.5 V, T_C = 150°C
							5.0	mA	V_{CE} = −100 V, V_{BE} = 1.5 V, T_C = 150°C
ON CHARACTERISTICS									
h_{FE}	DC Current Gain (Note 1)	750	18 k	750	18 k	750	18 k		I_C = 6.0 A, V_{CE} = −3.0 V
		100		100		100			I_C = 12 A, V_{CE} = −3.0 V
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage (Note 1)		−2.0		−2.0		−2.0	V	I_C = 6.0 A, I_B = 24 mA
			−3.0		−3.0		−3.0	V	I_C = 12 A, I_B = 120 mA
$V_{BE(sat)}$	Base-Emitter Saturation Voltage (Note 1)		−4.0		−4.0		−4.0	V	I_C = 12 A, I_B = 120 mA
$V_{BE(on)}$	Base-Emitter "On" Voltage (Note 1)		−2.8		−2.8		−2.8	V	I_C = 6.0 A, V_{CE} = −3.0 V
C_{ob}	Output Capacitance		500		500		500	pF	V_{CB} = −10 V, I_E = 0, f = 0.1 MHz
$\|h_{fe}\|$	Magnitude of Common Emitter Small Signal Short Circuit Forward Current Transfer Ratio	4.0		4.0		4.0			I_C = 5.0 A, V_{CE} = −3.0 V, f = 1.0 MHz
h_{fe}	Small Signal Current Gain	300		300		300			I_C = 5.0 A, V_{CE} = −3.0 V, f = 1.0 kHz

NOTE: 1. Pulse conditions: Length = 300 μs, Duty Cycle = 2%.

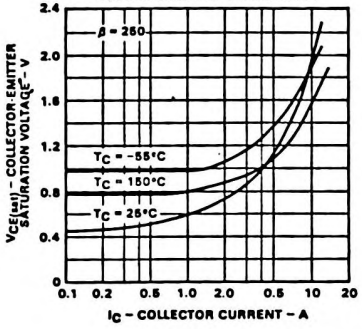
6

TYPICAL ELECTRICAL CHARACTERISTICS

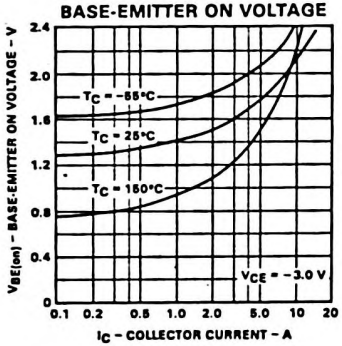
DC CURRENT GAIN



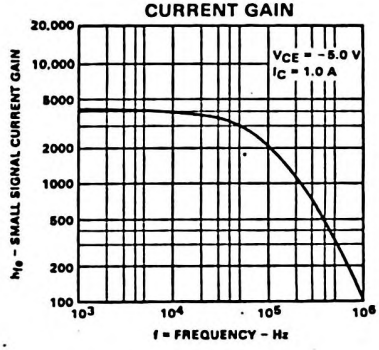
COLLECTOR-EMITTER SATURATION VOLTAGE



BASE-EMITTER ON VOLTAGE



SMALL SIGNAL CURRENT GAIN



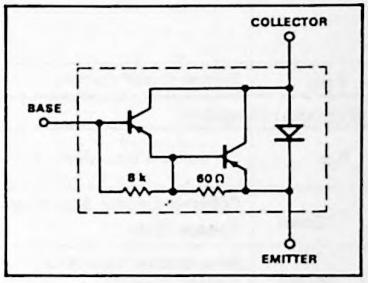
POWER DARLINGTON

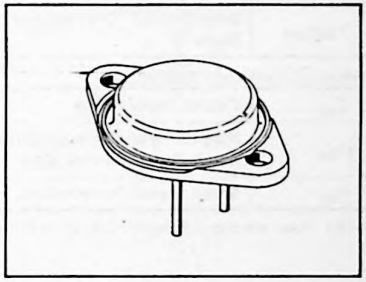
PNP SILICON

2N6053
2N6054

DESIGNED FOR GENERAL PURPOSE AMPLIFIER AND LOW SPEED SWITCHING APPLICATIONS

- 100 W DISSIPATION AT 25°C CASE
- 8.0 A MAXIMUM CONTINUOUS COLLECTOR CURRENT
- h_{FE} TYPICAL OF 4000 AT 4.0 A
- COMPLEMENT TO 2N6055, 2N6056

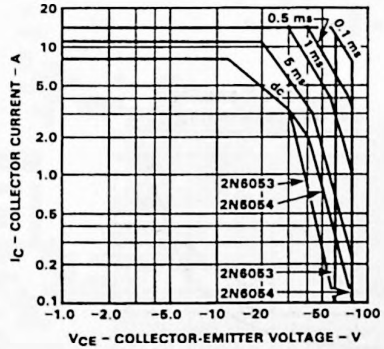




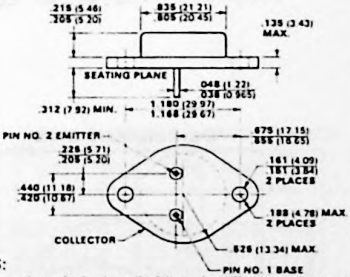
ABSOLUTE MAXIMUM RATINGS

		2N6053	2N6054
Maximum Voltages and Currents			
V_{CE}	Collector to Emitter Voltage	−60 V	−80 V
V_{CB}	Collector to Base Voltage	−60 V	−80 V
V_{EB}	Emitter to Base Voltage	−5.0 V	−5.0 V
I_C	Continuous Collector Current	8.0 A	8.0 A
I_C	Peak Collector Current	16 A	16 A
I_B	Continuous Base Current	0.12 A	0.12 A
Maximum Power Dissipation			
P_D	Total Dissipation @ 25°C Case Temperature		100 W
	Derate Linearly from 25°C		0.57 W/°C
Maximum Temperatures			
T_J, T_{stg}	Storage and Operation Junction Temperatures		−65°C to +200°C
Thermal Characteristics			
$R_{\theta JC}$	Thermal Resistance, Junction to Case		1.75°C/W
T_P	Maximum Pin Temperature (Soldering, 10 s)		235°C

SAFE OPERATING AREA



JEDEC (TO-3) Outline



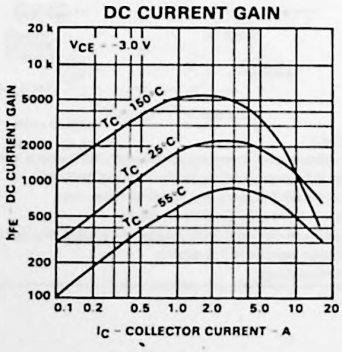
NOTES:
All dimensions in inches (bold) and millimeters (parentheses)
Pins are gold-plated or solder-dipped alloy 52
Pins 1 and 2 electrically isolated from case
Case is third electrical connection
Aluminum package with copper slug, pins are soldered in
Package weight is 7.4 grams
Aluminum cap

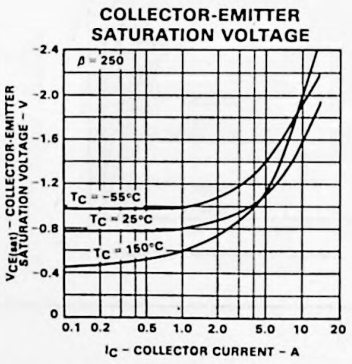
ELECTRICAL CHARACTERISTICS (25°C Case Temperature unless otherwise noted)

SYMBOL	CHARACTERISTIC	2N6053 MIN	2N6053 MAX	2N6054 MIN	2N6054 MAX	UNIT	TEST CONDITIONS
OFF CHARACTERISTICS							
$V_{CEO(sus)}$	Collector-Emitter Sustaining Voltage (Note 1)	−60		−80		V	I_C = 100 mA, I_B = 0
I_{CEO}	Collector Cutoff Current		0.5		0.5	mA	V_{CE} = −30 V, I_B = 0 V_{CE} = −40 V, I_B = 0
I_{CEX}	Collector Cutoff Current		0.5 5.0		0.5 5.0	mA mA mA mA	V_{CE} = −60 V, V_{BE} = 1.5 V, V_{CE} = −80 V, V_{BE} = 1.5 V, V_{CE} = −60 V, V_{BE} = 1.5 V, T_C = 150°C V_{CE} = −80 V, V_{BE} = 1.5 V, T_C = 150°C
I_{EBO}	Emitter Cutoff Current		2.0		2.0	mA	V_{EB} = −5.0 V, I_C = 0
ON CHARACTERISTICS							
h_{FE}	DC Current Gain (Note 1)	750 100	18 k	750 100	18 k		I_C = 4.0 A, V_{CE} = −3.0 V I_C = 8.0 A, V_{CE} = −3.0 V
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage (Note 1)		−2.0 −3.0		−2.0 −3.0	V V	I_C = 4.0 A, I_B = 16 mA I_C = 8.0 A, I_B = 80 mA
$V_{BE(sat)}$	Base-Emitter Saturation Voltage (Note 1)		−4.0		−4.0	V	I_C = 8.0 A, I_B = 80 mA
$V_{BE(on)}$	Base-Emitter "On" Voltage (Note 1)		−2.8		−2.8	V	I_C = 4.0 A, V_{CE} = −3.0 V
DYNAMIC CHARACTERISTICS							
C_{ob}	Output Capacitance		300		300	pF	V_{CB} = −10 V, I_E = 0, f = 0.1 MHz
$\|h_{fe}\|$	Magnitude of Common Emitter Small Signal Current Gain	4.0		4.0			I_C = 3.0 A, V_{CE} = −3.0 V, f = 1.0 MHz
h_{fe}	Small Signal Current Gain	300		300			I_C = 3.0 A, V_{CE} = −3.0 V, f = 1.0 kHz

NOTE 1: Pulse conditions: Length = 300 μs, Duty Cycle = 2%.

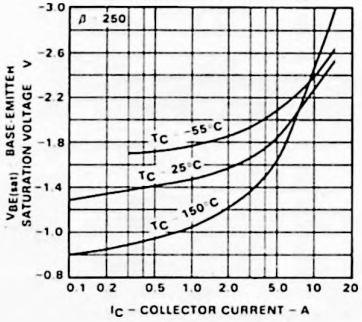
TYPICAL ELECTRICAL CHARACTERISTICS



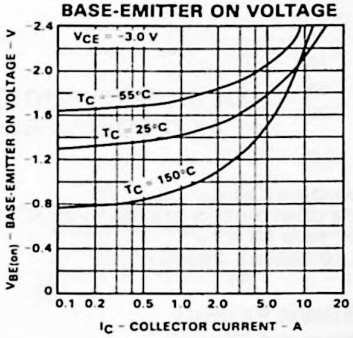


TYPICAL ELECTRICAL CHARACTERISTICS (Cont'd)

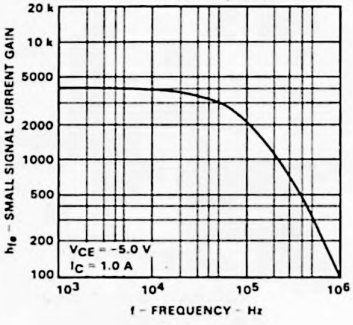
BASE-EMITTER SATURATION VOLTAGE



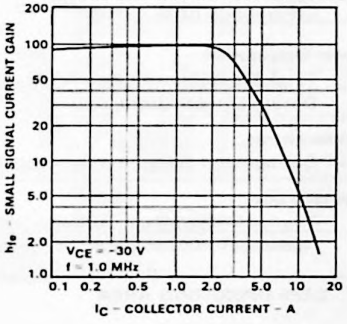
BASE-EMITTER ON VOLTAGE



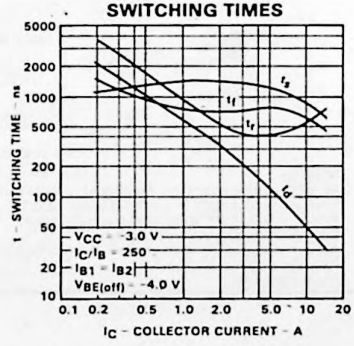
SMALL SIGNAL CURRENT GAIN



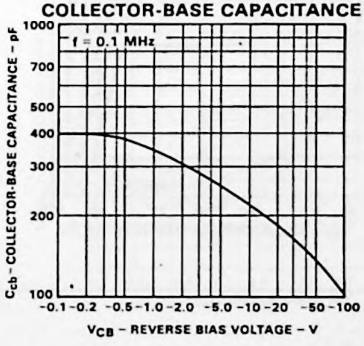
SMALL SIGNAL CURRENT GAIN



SWITCHING TIMES



COLLECTOR-BASE CAPACITANCE



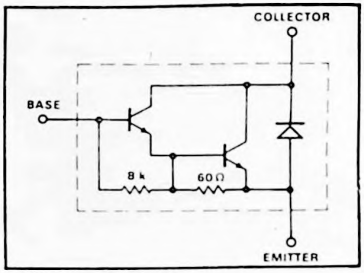
POWER DARLINGTON

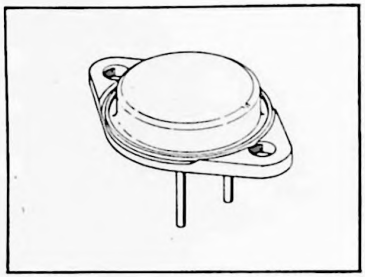
NPN SILICON

2N6055
2N6056

DESIGNED FOR GENERAL PURPOSE AMPLIFIER AND LOW SPEED SWITCHING APPLICATIONS

- 100 W DISSIPATION AT 25°C CASE
- 8.0 A MAXIMUM CONTINUOUS COLLECTOR CURRENT
- h_{FE} TYPICAL OF 4000 AT 4.0 A
- COMPLEMENT TO 2N6053, 2N6054

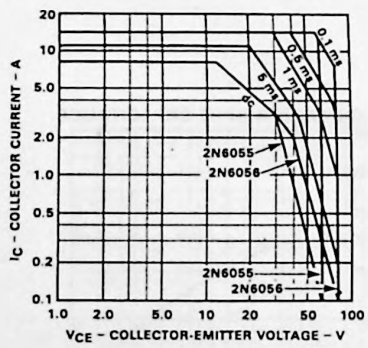




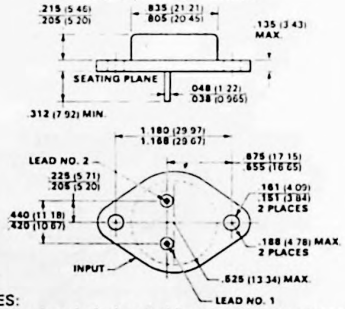
ABSOLUTE MAXIMUM RATINGS

		2N6055	2N6056
Maximum Voltages and Currents			
V_{CE}	Collector to Emitter Voltage	60 V	80 V
V_{CB}	Collector to Base Voltage	60 V	80 V
V_{EB}	Emitter to Base Voltage	5.0 V	5.0 V
I_C	Continuous Collector Current	8.0 A	8.0 A
I_C	Peak Collector Current	16 A	16 A
I_B	Continuous Base Current	0.12 A	0.12 A
Maximum Power Dissipation			
P_D	Total Dissipation @ 25°C Case Temperature		100 W
	Derate Linearly from 25°C		0.57 W/°C
Maximum Temperatures			
T_J, T_{stg}	Storage and Operation Junction Temperatures		−65°C to +200°C
Thermal Characteristics			
$R_{\theta JC}$	Thermal Resistance, Junction to Case		1.75°C/W
T_P	Maximum Pin Temperature (Soldering, 10 s)		235°C

SAFE OPERATING AREA



JEDEC (TO-3) Outline



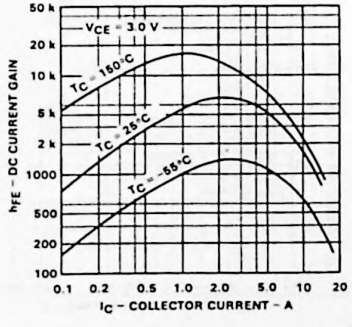
NOTES:
All dimensions in inches (bold) and millimeters (parentheses)
Pins are gold-plated or solder-dipped alloy 52
Pins 1 and 2 electrically isolated from case
Case is third electrical connection
Aluminum package with copper slug, pins are soldered in
Package weight is 7.4 grams
Aluminum cap

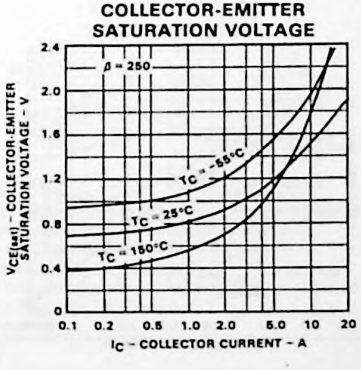
ELECTRICAL CHARACTERISTICS (25°C Case Temperature unless otherwise noted)

SYMBOL	CHARACTERISTIC	2N6055 MIN	2N6055 MAX	2N6056 MIN	2N6056 MAX	UNIT	TEST CONDITIONS
OFF CHARACTERISTICS							
$V_{CEO(sus)}$	Collector-Emitter Sustaining Voltage (Note 1)	60		80		V	I_C = 100 mA, I_B = 0
I_{CEO}	Collector Cutoff Current		0.5		0.5	mA	V_{CE} = 30 V, I_B = 0 V_{CE} = 40 V, I_B = 0
I_{CEX}	Collector Cutoff Current		0.5		0.5	mA	V_{CE} = 60 V, V_{BE} = −1.5 V
						mA	V_{CE} = 80 V, V_{BE} = −1.5 V
			5.0			mA	V_{CE} = 60 V, V_{BE} = −1.5 V, T_C = 150°C
					5.0	mA	V_{CE} = 80 V, V_{BE} = −1.5 V, T_C = 150°C
I_{EBO}	Emitter Cutoff Current		2.0		2.0	mA	V_{EB} = 5.0 V, I_C = 0
ON CHARACTERISTICS							
h_{FE}	DC Current Gain (Note 1)	750	18 k	750	18 k		I_C = 4.0 A, V_{CE} = 3.0 V
		100		100			I_C = 8.0 A, V_{CE} = 3.0 V
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage (Note 1)		2.0		2.0	V	I_C = 4.0 A, I_B = 16 mA
			3.0		3.0	V	I_C = 8.0 A, I_B = 80 mA
$V_{BE(sat)}$	Base-Emitter Saturation Voltage (Note 1)		4.0		4.0	V	I_C = 8.0 A, I_B = 80 mA
$V_{BE(on)}$	Base-Emitter "On" Voltage (Note 1)		2.8		2.8	V	I_C = 4.0 A, V_{CE} = 3.0 V
DYNAMIC CHARACTERISTICS							
C_{ob}	Output Capacitance		200		200	pF	V_{CB} = 10 V, I_E = 0, f = 0.1 MHz
$\|h_{fe}\|$	Magnitude of Common Emitter Small Signal Current Gain	4.0		4.0			I_C = 3.0 A, V_{CE} = 3.0 V, f = 1.0 MHz
h_{fe}	Small Signal Current Gain	300		300			I_C = 3.0 A, V_{CE} = 3.0 V, f = 1.0 kHz

NOTE 1: Pulse conditions: Length = 300 μs, Duty Cycle = 2%.

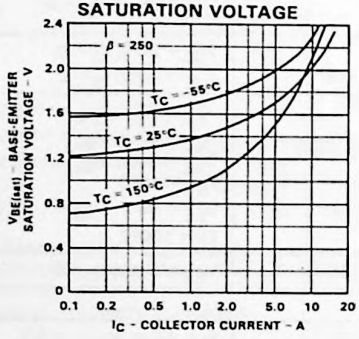
TYPICAL ELECTRICAL CHARACTERISTICS



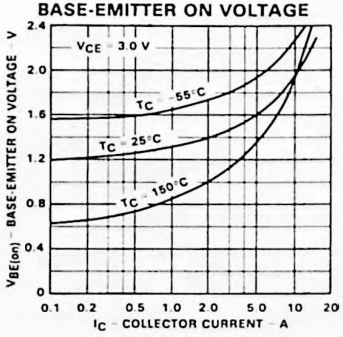


TYPICAL ELECTRICAL CHARACTERISTICS (Cont'd)

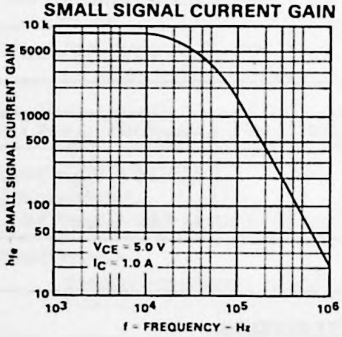
BASE-EMITTER SATURATION VOLTAGE



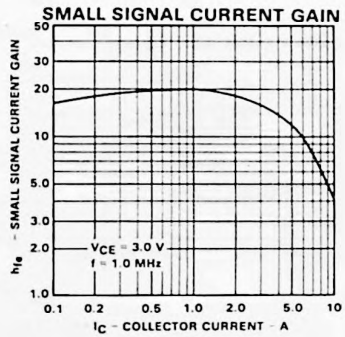
BASE-EMITTER ON VOLTAGE



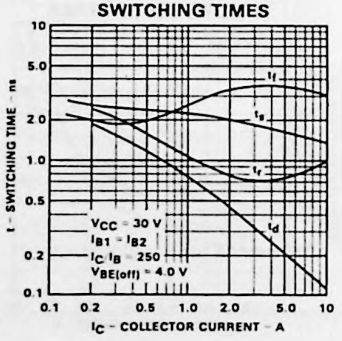
SMALL SIGNAL CURRENT GAIN



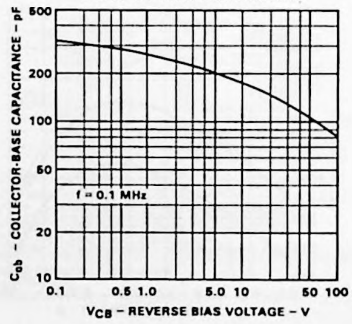
SMALL SIGNAL CURRENT GAIN



SWITCHING TIMES



OUTPUT CAPACITANCE



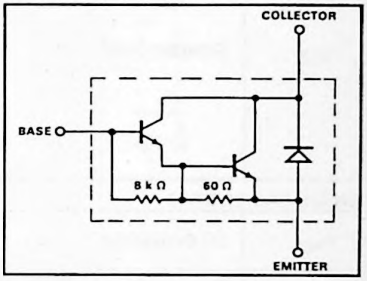
POWER DARLINGTON

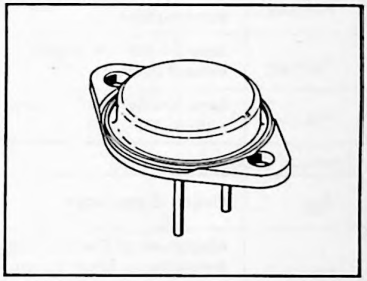
NPN SILICON

2N6057
2N6058
2N6059

DESIGNED FOR GENERAL PURPOSE AMPLIFIERS AND LOW SPEED SWITCHING APPLICATIONS

- 150 W DISSIPATION AT 25°C CASE
- 12 A MAXIMUM CONTINUOUS COLLECTOR CURRENT
- h_{FE} TYPICAL OF 4000 AT 3.0 A
- COMPLEMENT TO 2N6050, 2N6051, 2N6052





ABSOLUTE MAXIMUM RATINGS

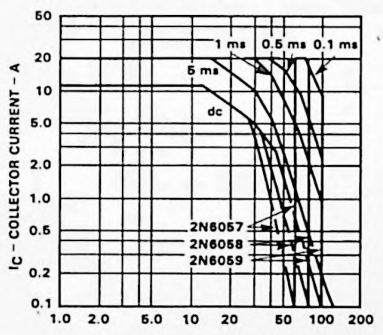
Maximum Voltages and Currents		2N6057	2N6058	2N6059
V_{CE}	Collector to Emitter Voltage	60 V	80 V	100 V
V_{CB}	Collector to Base Voltage	60 V	80 V	100 V
V_{EB}	Emitter to Base Voltage	5.0 V	5.0 V	5.0 V
I_C	Continuous Collector Current	12 A	12 A	12 A
I_C	Peak Collector Current	20 A	20 A	20 A
I_B	Continuous Base Current	0.2 A	0.2 A	0.2 A

Maximum Power Dissipation		
P_D	Total Dissipation @ 25°C Case Temperature	150 W
	Derate Linearly from 25°C	0.857 W/°C

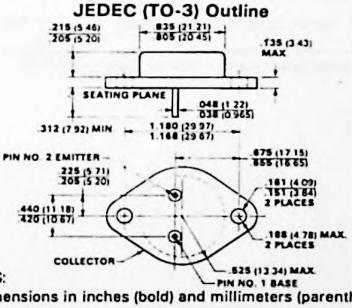
Maximum Temperatures		
T_J, T_{stg}	Storage and Operation Junction Temperatures	−65°C to +200°C

Thermal Characteristics		
$R_{\theta JC}$	Thermal Resistance, Junction to Case	1.17 °C/W
T_P	Maximum Pin Temperature (Soldering, 10 s)	235°C

SAFE OPERATING AREA



JEDEC (TO-3) Outline



NOTES:
All dimensions in inches (bold) and millimeters (parentheses)
Pins are gold-plated or solder-dipped alloy 52
Pins 1 and 2 electrically isolated from case
Case is third electrical connection
Aluminum package with copper slug, pins are soldered in
Package weight is 7.4 grams
Aluminum cap

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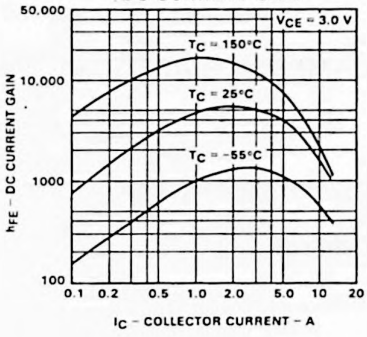
ELECTRICAL CHARACTERISTICS (25°C Case Temperature unless otherwise noted)

SYMBOL	CHARACTERISTIC	2N6057		2N6058		2N6059		UNITS	TEST CONDITIONS
		MIN	MAX	MIN	MAX	MIN	MAX		
OFF CHARACTERISTICS									
$V_{CEO(sus)}$	Collector-Emitter Sustaining Voltage (Note 1)	60		80		100		V	I_C = 100 mA, I_B = 0
I_{CEO}	Collector Cutoff Current		1.0		1.0			mA	V_{CE} = 30 V, I_B = 0
							1.0	mA	V_{CE} = 40 V, I_B = 0
								mA	V_{CE} = 50 V, I_B = 0
I_{EBO}	Emitter Cutoff Current		2.0		2.0		2.0	mA	V_{EB} = 5.0 V, I_C = 0
I_{CEX}	Collector Cutoff Current		1.0		1.0			mA	V_{CE} = 60 V, V_{BE} = −1.5 V
							1.0	mA	V_{CE} = 80 V, V_{BE} = −1.5 V
								mA	V_{CE} = 100 V, V_{BE} = −1.5 V
			5.0					mA	V_{CE} = 60 V, V_{BE} = −1.5 V, T_C = 150°C
					5.0			mA	V_{CE} = 80 V, V_{BE} = −1.5 V, T_C = 150°C
							5.0	mA	V_{CE} = 100 V, V_{BE} = −1.5 V, T_C = 150°C
ON CHARACTERISTICS									
h_{FE}	DC Current Gain (Note 1)	750	18 k	750	18 k	750	18 k		I_C = 6.0 A, V_{CE} = 3.0 V
		100		100		100			I_C = 12 A, V_{CE} = 3.0 V
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage (Note 1)		2.0		2.0		2.0	V	I_C = 6.0 A, I_B = 24 mA
			3.0		3.0		3.0	V	I_C = 12 A, I_B = 120 mA
$V_{BE(sat)}$	Base-Emitter Saturation Voltage (Note 1)		4.0		4.0		4.0	V	I_C = 12 A, I_B = 120 mA
$V_{BE(on)}$	Base-Emitter "On" Voltage (Note 1)		2.8		2.8		2.8	V	I_C = 6.0 A, V_{CE} = 3.0 V
DYNAMIC CHARACTERISTICS									
C_{ob}	Output Capacitance		300		300		300	pF	V_{CB} = 10 V, I_E = 0, f = 0.1 MHz
$\lvert h_{fe} \rvert$	Magnitude of Common Emitter Small Signal Short Circuit Forward Current Transfer Ratio	4.0		4.0		4.0			I_C = 5.0 A, V_{CE} = 3.0 V, f = 1.0 MHz
h_{fe}	Small Signal Current Gain	300		300		300			I_C = 5.0 A, V_{CE} = 3.0 V, f = 1.0 kHz

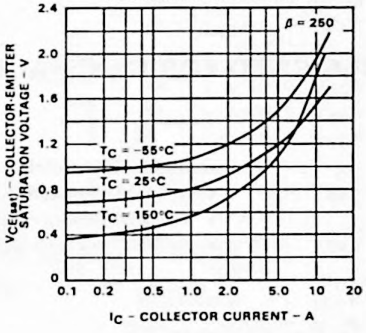
NOTE: 1. Pulse conditions: Length = 300 μs, Duty Cycle = 2%.

TYPICAL ELECTRICAL CHARACTERISTICS

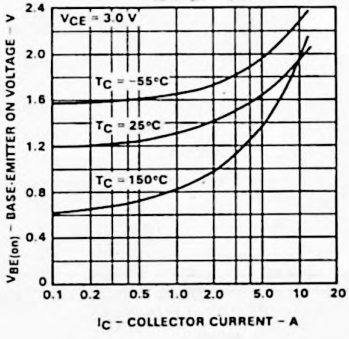
DC CURRENT GAIN



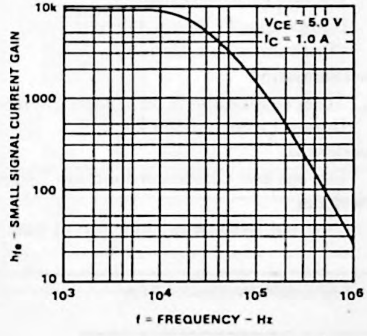
COLLECTOR-EMITTER SATURATION VOLTAGE



BASE-EMITTER ON VOLTAGE



SMALL SIGNAL CURRENT GAIN



6

POWER TRANSISTOR

NPN SILICON

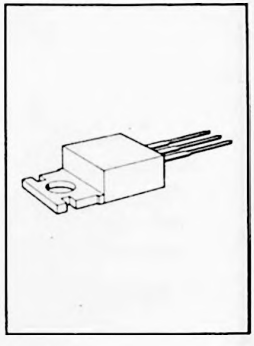
2N6121
2N6122
2N6123

DESIGNED FOR GENERAL PURPOSE AMPLIFIER APPLICATIONS

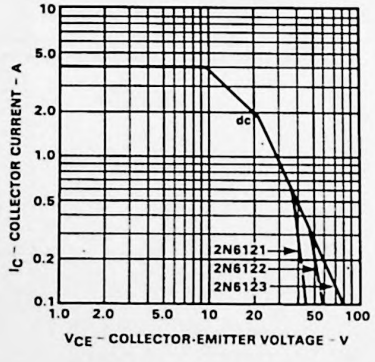
- 40 W DISSIPATION AT 25°C CASE
- 4.0 A MAXIMUM CONTINUOUS COLLECTOR CURRENT
- 0.6 V MAXIMUM $V_{CE(sat)}$ @ 1.5 A
- COMPLEMENTS 2N6124, 2N6125, 2N6126

ABSOLUTE MAXIMUM RATINGS (Note 1)

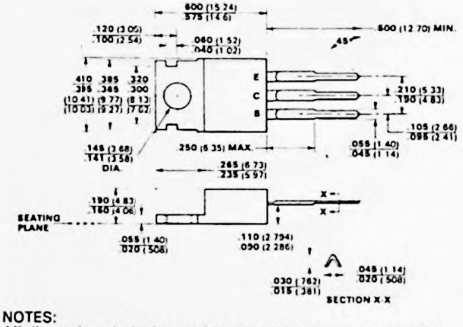
		2N6121	2N6122	2N6123
Maximum Voltages and Currents				
V_{CEO}	Collector to Emitter Voltage	45 V	60 V	80 V
V_{CBO}	Collector to Base Voltage	45 V	60 V	80 V
V_{EBO}	Emitter to Base Voltage	5.0 V	5.0 V	5.0 V
I_C	Continuous Collector Current	4.0 A	4.0 A	4.0 A
I_B	Continuous Base Current	1.0 A	1.0 A	1.0 A
Maximum Power Dissipation				
P_D	Total Dissipation @ 25°C Case Temperature			40 W
	Derate Linearly from 25°C			0.32 W/°C
Maximum Temperatures				
T_J, T_{stg}	Storage and Operation Junction Temperatures			−65°C to +150°C
Thermal Characteristics				
$R_{\theta JC}$	Thermal Resistance, Junction to Case			3.12°C/W



SAFE OPERATING AREA



JEDEC (TO-220) Outline**



NOTES:
All dimensions in inches (bold) and millimeters (parentheses)
Package is silicone plastic with nickel-plated copper tab and pins
*Mechanically interchangeable with TO-66
Center pin is electrical contact with the mounting tab
Package weight is 2.1 grams
**Available in various pin configurations

ELECTRICAL CHARACTERISTICS (25°C Case Temperature unless otherwise noted)

SYMBOL	CHARACTERISTIC	2N6121		2N6122		2N6123		UNIT	TEST CONDITIONS
		MIN	MAX	MIN	MAX	MIN	MAX		
OFF CHARACTERISTICS									
$V_{CEO(sus)}$	Collector-Emitter Sustaining Voltage (Note 1)	45		60		80		V	I_C = 100 mA, I_B = 0
I_{CEO}	Collector Cutoff Current		1.0		1.0		1.0	mA mA mA	V_{CE} = 45 V, I_B = 0 V_{CE} = 60 V, I_B = 0 V_{CE} = 80 V, I_B = 0
I_{CEX}	Collector Cutoff Current		0.1 2.0		0.1 2.0		0.1 2.0	mA mA mA mA mA mA	V_{CE} = 45 V, V_{BE} = −1.5 V V_{CE} = 60 V, V_{BE} = −1.5 V V_{CE} = 80 V, V_{BE} = −1.5 V V_{CE} = 45 V, V_{BE} = −1.5 V T_C = 125°C V_{CE} = 60 V, V_{BE} = −1.5 V T_C = 125°C V_{CE} = 80 V, V_{BE} = −1.5 V T_C = 125°C
I_{CBO}	Collector Cutoff Current		0.1		0.1		0.1	mA mA mA	V_{CB} = 45 V, I_E = 0 V_{CB} = 60 V, I_E = 0 V_{CB} = 80 V, I_E = 0
I_{EBO}	Emitter Cutoff Current		1.0		1.0		1.0	mA	V_{EB} = 5.0 V, I_C = 0
ON CHARACTERISTICS									
h_{FE}	DC Current Gain (Note 1)	25 10	100	25 10	100	20 7.0	80		I_C = 1.5 A, V_{CE} = 2.0 V I_C = 4.0 A, V_{CE} = 2.0 V
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage (Note 1)		0.6 1.4		0.6 1.4		0.6 1.4	V V	I_C = 1.5 A, I_B = 0.15 A I_C = 4.0 A, I_B = 1.0 A
$V_{BE(on)}$	Base-Emitter "On" Voltage (Note 1)		1.2		1.2		1.2	V	I_C = 1.5 A, V_{CE} = 2.0 V
DYNAMIC CHARACTERISTICS									
h_{fe}	Magnitude of Common Emitter Small Signal Current Gain	2.5		2.5		2.5			I_C = 1.0 A, V_{CE} = 4.0 V, f = 1.0 MHz
h_{fe}	Small Signal Current Gain	25		25		25			I_C = 0.1 A, V_{CE} = 2.0 V, f = 1.0 kHz

NOTE: 1. Pulse conditions: Length = 300 μs, Duty Cycle = 2%.

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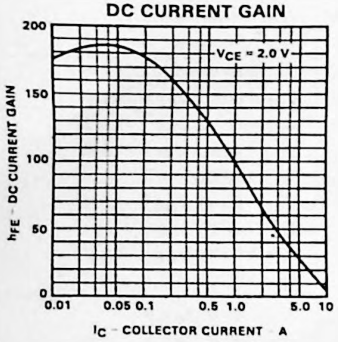
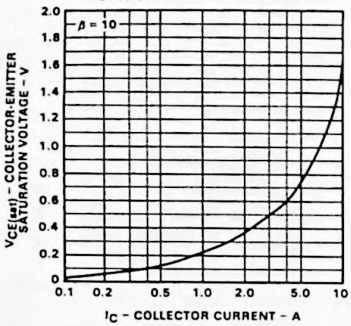
TYPICAL ELECTRICAL CHARACTERISTICS

2N6121 • 2N6122

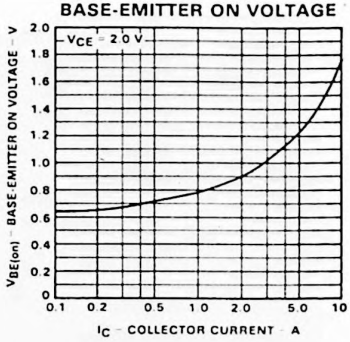
DC CURRENT GAIN



COLLECTOR-EMITTER SATURATION VOLTAGE

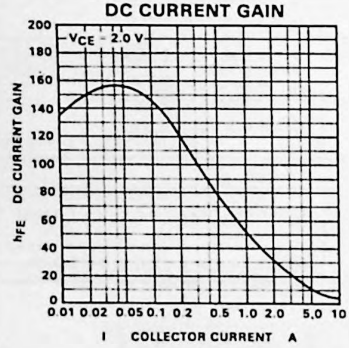


BASE-EMITTER ON VOLTAGE

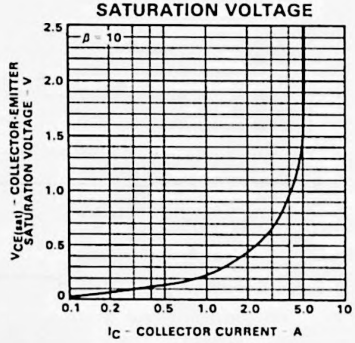


2N6123

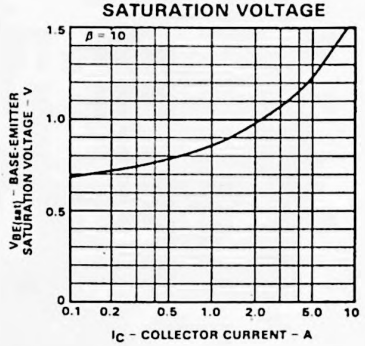
DC CURRENT GAIN



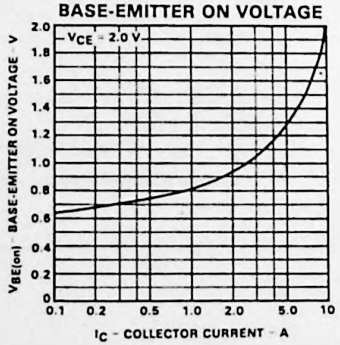
COLLECTOR-EMITTER SATURATION VOLTAGE



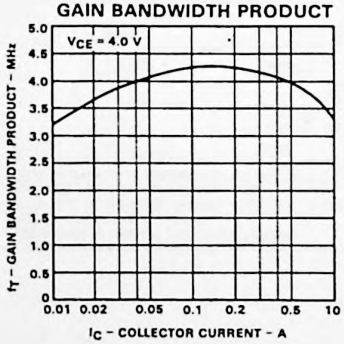
BASE-EMITTER SATURATION VOLTAGE



BASE-EMITTER ON VOLTAGE



GAIN BANDWIDTH PRODUCT



POWER TRANSISTOR

PNP SILICON

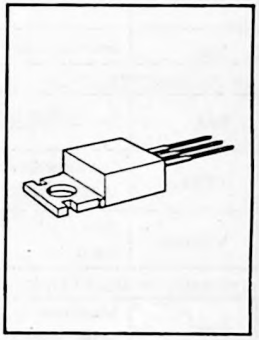
2N6124
2N6125
2N6126

DESIGNED FOR GENERAL PURPOSE AMPLIFIER APPLICATIONS

- 40 W DISSIPATION AT 25°C CASE
- 4.0 A MAXIMUM CONTINUOUS COLLECTOR CURRENT
- –0.6 V MAXIMUM $V_{CE(sat)}$ @ 1.5 A
- COMPLEMENTS 2N6121, 2N6122, 2N6123

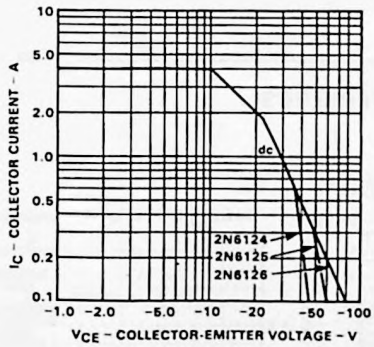
ABSOLUTE MAXIMUM RATINGS (Note 1)

		2N6124	2N6125	2N6126
Maximum Voltages and Currents				
V_{CEO}	Collector to Emitter Voltage	−45 V	−60 V	−80 V
V_{CBO}	Collector to Base Voltage	−45 V	−60 V	−80 V
V_{EBO}	Emitter to Base Voltage	−5.0 V	−5.0 V	−5.0 V
I_C	Continuous Collector Current	4.0 A	4.0 A	4.0 A
I_B	Continuous Base Current	1.0 A	1.0 A	1.0 A
Maximum Power Dissipation				
P_D	Total Dissipation @ 25°C Case Temperature			40 W
	Derate Linearly from 25°C			0.32 W/°C
Maximum Temperatures				
T_J, T_{stg}	Storage and Operation Junction Temperatures			−65°C to +150°C
Thermal Characteristics				
$R_{\theta JC}$	Thermal Resistance, Junction to Case			3.12°C/W

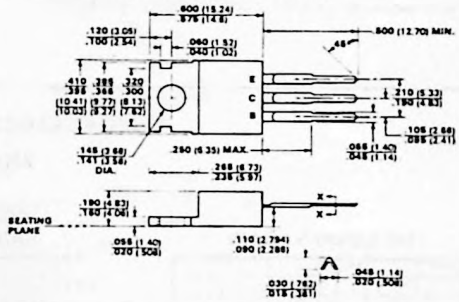


6

SAFE OPERATING AREA



JEDEC (TO-220) Outline**



NOTES:
All dimensions in inches (bold) and millimeters (parentheses)
Package is silicone plastic with nickel-plated copper tab and pins
*Mechanically interchangeable with TO-66
Center pin is electrical contact with the mounting tab
Package weight is 2.1 grams
**Available in various pin configurations

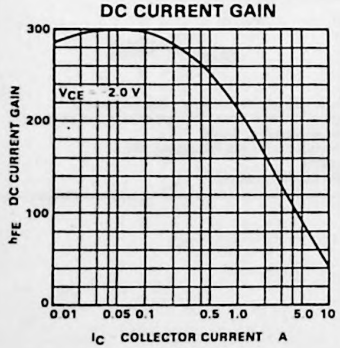
ELECTRICAL CHARACTERISTICS (25°C Case Temperature unless otherwise noted)

SYMBOL	CHARACTERISTIC	2N6124 MIN	2N6124 MAX	2N6125 MIN	2N6125 MAX	2N6126 MIN	2N6126 MAX	UNIT	TEST CONDITIONS
OFF CHARACTERISTICS									
$V_{CEO(sus)}$	Collector-Emitter Sustaining Voltage (Note 1)	−45		−60		−80		V	I_C = 100 mA, I_B = 0
I_{CEO}	Collector Cutoff Current		1.0		1.0			mA	V_{CE} = −45 V, I_B = 0
								mA	V_{CE} = −60 V, I_B = 0
							1.0	mA	V_{CE} = −80 V, I_B = 0
I_{CEX}	Collector Cutoff Current		0.1					mA	V_{CE} = −45 V, V_{BE} = 1.5 V
					0.1			mA	V_{CE} = −60 V, V_{BE} = 1.5 V
							0.1	mA	V_{CE} = −80 V, V_{BE} = 1.5 V
			2.0					mA	V_{CE} = −45 V, V_{BE} = 1.5 V, T_C = 125°C
					2.0			mA	V_{CE} = −60 V, V_{BE} = 1.5 V, T_C = 125°C
							2.0	mA	V_{CE} = −80 V, V_{BE} = 1.5 V, T_C = 125°C
I_{CBO}	Collector Cutoff Current		0.1					mA	V_{CB} = −45 V, I_E = 0
					0.1			mA	V_{CB} = −60 V, I_E = 0
							0.1	mA	V_{CB} = −80 V, I_E = 0
I_{EBO}	Emitter Cutoff Current		1.0		1.0		1.0	mA	V_{EB} = −5.0 V, I_C = 0
ON CHARACTERISTICS									
h_{FE}	DC Current Gain (Note 1)	25	100	25	100	20	80		I_C = 1.5 A, V_{CE} = −2.0 V
		10		10		7.0			I_C = 4.0 A, V_{CE} = −2.0 V
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage (Note 1)		−0.6		−0.6		−0.6	V	I_C = 1.5 A, I_B = 0.15 A
			−1.4		−1.4		−1.4	V	I_C = 4.0 A, I_B = 1.0 A
$V_{BE(on)}$	Base-Emitter "On" Voltage (Note 1)		−1.2		−1.2		−1.2	V	I_C = 1.5 A, V_{CE} = −2.0 V
DYNAMIC CHARACTERISTICS									
$\|h_{fe}\|$	Magnitude of Common Emitter Small Signal Current Gain	2.5		2.5		2.5			I_C = 1.0 A, V_{CE} = −4.0 V, f = 1.0 MHz
h_{fe}	Small Signal Current Gain	25		25		25			I_C = 0.1 A, V_{CE} = −2.0 V, f = 1.0 kHz

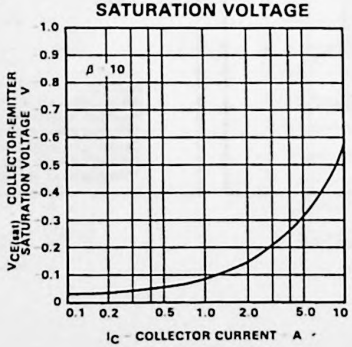
NOTE: 1. Pulse conditions: Length = 300 μs, Duty Cycle = 2%.

TYPICAL ELECTRICAL CHARACTERISTICS
2N6124 • 2N6125

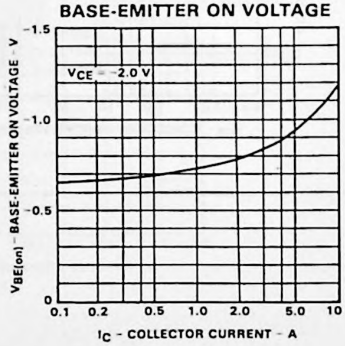
DC CURRENT GAIN



COLLECTOR-EMITTER SATURATION VOLTAGE



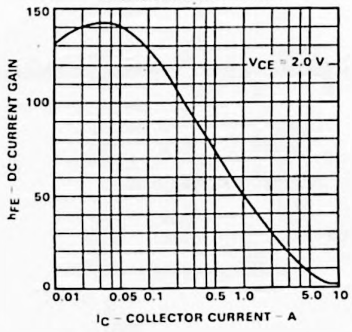
BASE-EMITTER ON VOLTAGE



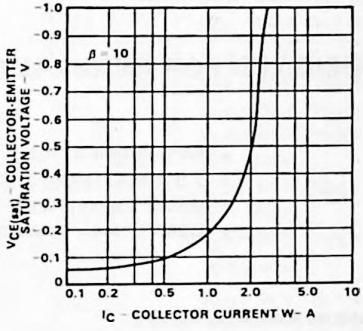
TYPICAL ELECTRICAL CHARACTERISTICS (Cont'd)

2N6126

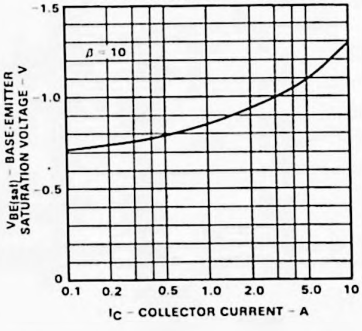
DC CURRENT GAIN



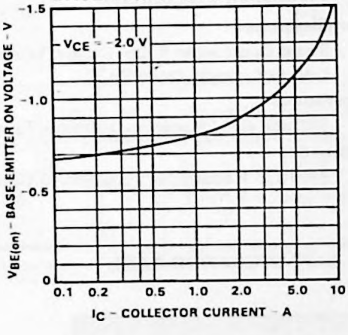
COLLECTOR-EMITTER SATURATION VOLTAGE



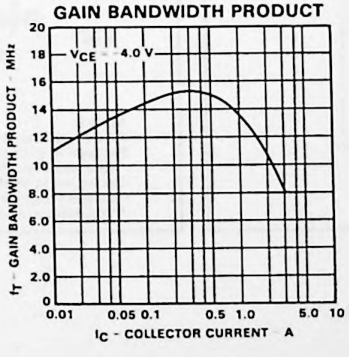
BASE-EMITTER SATURATION VOLTAGE



BASE-EMITTER ON VOLTAGE



GAIN BANDWIDTH PRODUCT



6

POWER TRANSISTOR

NPN SILICON

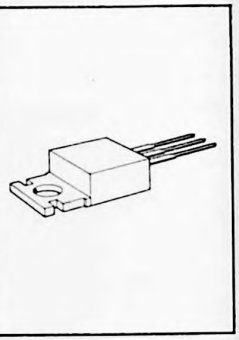
2N6129
2N6130
2N6131

DESIGNED FOR GENERAL PURPOSE AMPLIFIER APPLICATIONS

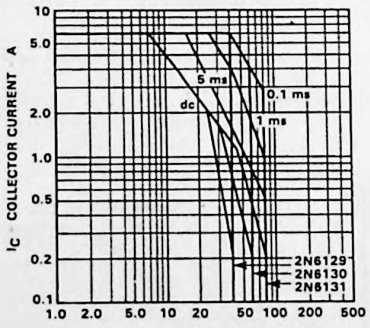
- 50 W DISSIPATION AT 25°C CASE
- 7.0 A MAXIMUM CONTINUOUS COLLECTOR CURRENT
- 20 TO 100 h_{FE} AT I_C 2.5 A
- COMPLEMENTS 2N6132, 2N6133, 2N6134

ABSOLUTE MAXIMUM RATINGS (Note 1)

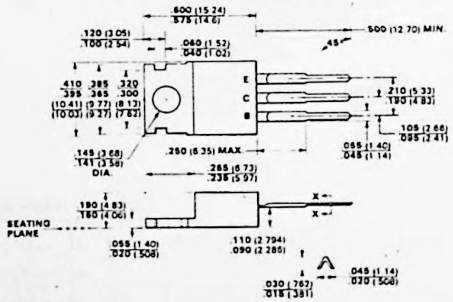
		2N6129	2N6130	2N6131
Maximum Voltages and Currents				
V_{CEO}	Collector to Emitter Voltage	40 V	60 V	80 V
V_{CBO}	Collector to Base Voltage	40 V	60 V	80 V
V_{EBO}	Emitter to Base Voltage	5.0 V	5.0 V	5.0 V
I_C	Continuous Collector Current	7.0 A	7.0 A	7.0 A
I_B	Continuous Base Current	3.0 A	3.0 A	3.0 A
Maximum Power Dissipation				
P_D	Total Dissipation @ 25°C Case Temperature			50 W
	Derate Linearly from 25°C			0.4 W/°C
Maximum Temperatures				
T_J, T_{stg}	Storage and Operation Junction Temperatures			−65°C to +150°C
Thermal Characteristics				
$R_{\theta JC}$	Thermal Resistance, Junction to Case			2.5°C/W



SAFE OPERATING AREA



JEDEC (TO-220) Outline**



NOTES:
All dimensions in inches (bold) and millimeters (parentheses)
Package is silicone plastic with nickel-plated copper tab and pins
*Mechanically interchangeable with TO-66
Center pin is electrical contact with the mounting tab
Package weight is 2.1 grams
**Available in various pin configurations

ELECTRICAL CHARACTERISTICS (25°C Case Temperature unless otherwise noted)

SYMBOL	CHARACTERISTIC	2N6129		2N6130		2N6131		UNIT	TEST CONDITIONS
		MIN	MAX	MIN	MAX	MIN	MAX		
OFF CHARACTERISTICS									
$V_{CEO(sus)}$	Collector-Emitter Sustaining Voltage (Note 1)	40		60		80		V	I_C = 100 mA, I_B = 0
I_{CEO}	Collector Cutoff Current		2.0					mA	V_{CE} = 40 V, I_B = 0
					2.0			mA	V_{CE} = 60 V, I_B = 0
							2.0	mA	V_{CE} = 80 V, I_B = 0
I_{CEX}	Collector Cutoff Current		0.2					mA	V_{CE} = 40 V, V_{BE} = −1.5 V
					0.2			mA	V_{CE} = 60 V, V_{BE} = −1.5 V
							0.2	mA	V_{CE} = 80 V, V_{BE} = −1.5 V
			2.0					mA	V_{CE} = 40 V, V_{BE} = −1.5 V, T_C = 125°C
					2.0			mA	V_{CE} = 60 V, V_{BE} = −1.5 V, T_C = 125°C
							2.0	mA	V_{CE} = 80 V, V_{BE} = −1.5 V, T_C = 125°C
I_{CBO}	Collector Cutoff Current		0.5					mA	V_{CB} = 40 V, I_E = 0
					0.5			mA	V_{CB} = 60 V, I_E = 0
							0.5	mA	V_{CB} = 80 V, I_E = 0
I_{EBO}	Emitter Cutoff Current		1.0		1.0		1.0	mA	V_{EB} = 5.0 V, I_C = 0
ON CHARACTERISTICS									
h_{FE}	DC Current Gain (Note 1)	20	100	20	100	20	100		I_C = 2.5 A, V_{CE} = 4.0 V
		7.0		7.0		5.0			I_C = 7.0 A, V_{CE} = 4.0 V
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage (Note 1)		1.4		1.4		1.8	V	I_C = 7.0 A, I_B = 3.0 A
$V_{BE(on)}$	Base-Emitter "On" Voltage (Note 1)		2.0		2.0		2.0	V	I_C = 2.5 A, V_{CE} = 4.0 V
DYNAMIC CHARACTERISTICS									
$\lvert h_{fe} \rvert$	Magnitude of Common Emitter Small Signal Current Gain	2.5		2.5		2.5			I_C = 1.0 A, V_{CE} = 4.0 V, f = 1.0 MHz
h_{fe}	Small Signal Current Gain	25		25		25			I_C = 0.1 A, V_{CE} = 4.0 V, f = 1.0 kHz

NOTE: 1. Pulse conditions: Length = 300 μs, Duty Cycle = 2%.

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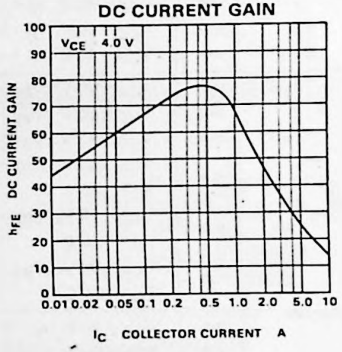
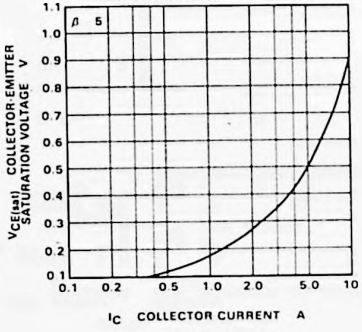
TYPICAL ELECTRICAL CHARACTERISTICS

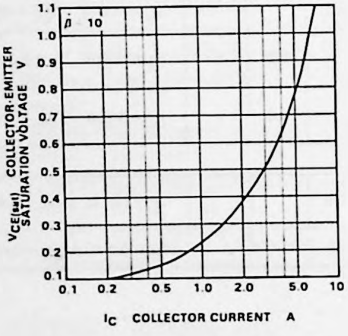
DC CURRENT GAIN



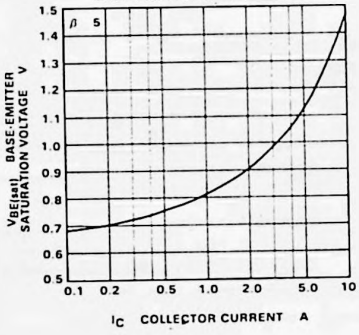
COLLECTOR-EMITTER SATURATION VOLTAGE



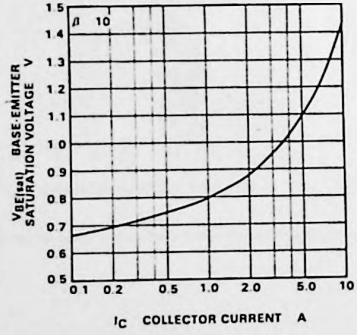
COLLECTOR-EMITTER SATURATION VOLTAGE



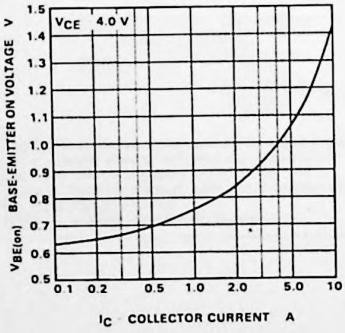
BASE-EMITTER SATURATION VOLTAGE



BASE-EMITTER SATURATION VOLTAGE



BASE-EMITTER ON VOLTAGE



POWER TRANSISTOR

PNP SILICON

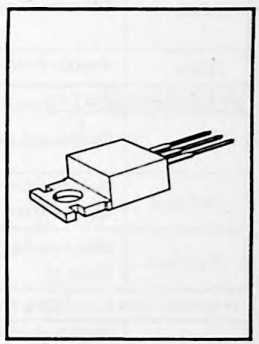
2N6132
2N6133
2N6134

DESIGNED FOR GENERAL PURPOSE AMPLIFIER APPLICATIONS

- 50 W DISSIPATION AT 25°C CASE
- 7 A MAXIMUM CONTINUOUS COLLECTOR CURRENT
- 20 TO 100 h_{FE} AT I_C 2.5 A
- COMPLEMENTS 2N6129, 2N6130, 2N6131

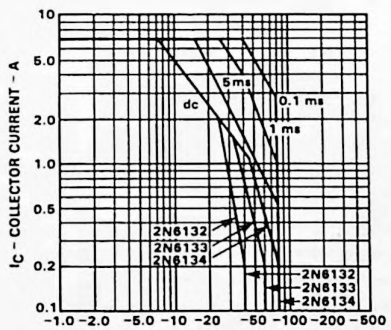
ABSOLUTE MAXIMUM RATINGS (Note 1)

		2N6132	2N6133	2N6134
Maximum Voltages and Currents				
V_{CEO}	Collector to Emitter Voltage	−40 V	−60 V	−80 V
V_{CBO}	Collector to Base Voltage	−40 V	−60 V	−80 V
V_{EBO}	Emitter to Base Voltage	−5.0 V	−5.0 V	−5.0 V
I_C	Continuous Collector Current	7.0 A	7.0 A	7.0 A
I_B	Continuous Base Current	3.0 A	3.0 A	3.0 A
Maximum Power Dissipation				
P_D	Total Dissipation @ 25°C Case Temperature			50 W
	Derate Linearly from 25°C			0.4 W/°C
Maximum Temperatures				
T_J, T_{stg}	Storage and Operation Junction Temperatures			−65°C to +150°C
Thermal Characteristics				
$R_{\theta JC}$	Thermal Resistance, Junction to Case			2.5°C/W

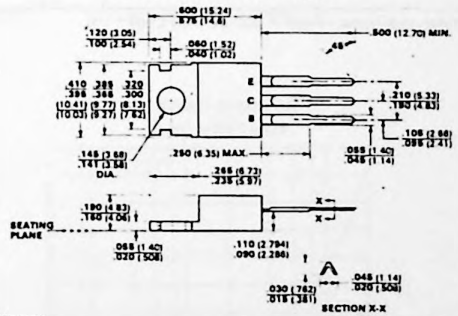


6

SAFE OPERATING AREA



JEDEC (TO-220) Outline**



NOTES:
All dimensions in inches (bold) and millimeters (parentheses)
Package is silicone plastic with nickel-plated copper tab and pins
*Mechanically interchangeable with TO-66
Center pin is electrical contact with the mounting tab
Package weight is 2.1 grams
**Available in various pin configurations

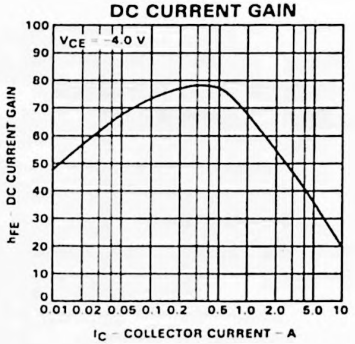
ELECTRICAL CHARACTERISTICS (25°C Case Temperature unless otherwise noted)

SYMBOL	CHARACTERISTIC	2N6132		2N6133		2N6134		UNIT	TEST CONDITIONS
		MIN	MAX	MIN	MAX	MIN	MAX		
OFF CHARACTERISTICS									
$V_{CEO(sus)}$	Collector-Emitter Sustaining Voltage (Note 1)	–40		–60		–80		V	I_C = 100 mA, I_B = 0
I_{CEO}	Collector Cutoff Current		2.0		2.0		2.0	mA mA mA	V_{CE} = –40 V, I_B = 0 V_{CE} = –60 V, I_B = 0 V_{CE} = –80 V, I_B = 0
I_{CEX}	Collector Cutoff Current	2.0	0.2		0.2 2.0		0.2 2.0	mA mA mA mA mA mA mA	V_{CE} = –40 V, V_{BE} = 1.5 V V_{CE} = –60 V, V_{BE} = 1.5 V V_{CE} = –80 V, V_{BE} = 1.5 V V_{CE} = –40 V, V_{BE} = 1.5 V, T_C = 125°C V_{CE} = –60 V, V_{BE} = 1.5 V, T_C = 125°C V_{CE} = –80 V, V_{BE} = 1.5 V, T_C = 125°C
I_{CBO}	Collector Cutoff Current		0.5		0.5		0.5	mA mA mA	V_{CB} = –40 V, I_E = 0 V_{CB} = –60 V, I_E = 0 V_{CB} = –80 V, I_E = 0
I_{EBO}	Emitter Cutoff Current		1.0		1.0		1.0	mA	V_{EB} = –5.0 V, I_C = 0
ON CHARACTERISTICS									
h_{FE}	DC Current Gain (Note 1)	20 7.0	100	20 7.0	100	20 5.0	100		I_C = 2.5 A, V_{CE} = –4.0 V I_C = 7.0 A, V_{CE} = –4.0 V
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage (Note 1)		–1.4		–1.4		–1.8	V	I_C = 7.0 A, I_B = 3.0 A
$V_{BE(on)}$	Base-Emitter "On" Voltage (Note 1)		–2.0		–2.0		–2.0	V	I_C = 2.5 A, V_{CE} = –4.0 V
DYNAMIC CHARACTERISTICS									
$\|h_{fe}\|$	Magnitude of Common Emitter Small Signal Current Gain	2.5		2.5		2.5			I_C = 1.0 A, V_{CE} = –4.0 V, f = 1.0 MHz
h_{fe}	Small Signal Current Gain	25		25		25			I_C = 0.1 A, V_{CE} = –4.0 V, f = 1.0 kHz

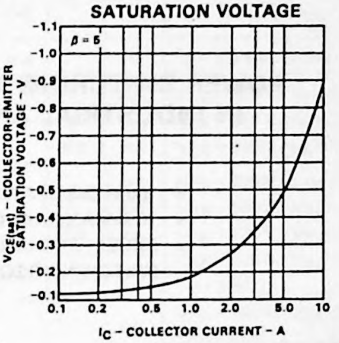
NOTE: 1. Pulse conditions: Length = 300 μs, Duty Cycle= 2%.

TYPICAL ELECTRICAL CHARACTERISTICS

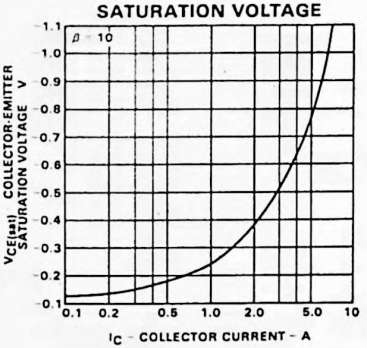
DC CURRENT GAIN



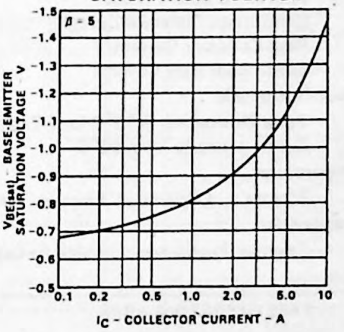
COLLECTOR-EMITTER SATURATION VOLTAGE



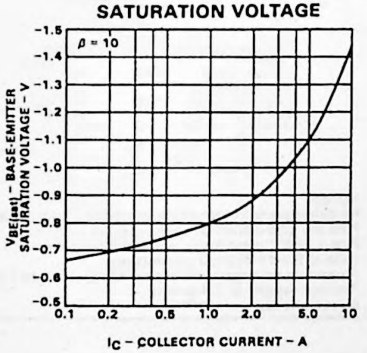
COLLECTOR-EMITTER SATURATION VOLTAGE



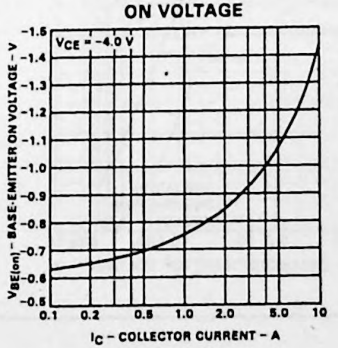
BASE-EMITTER SATURATION VOLTAGE



BASE-EMITTER SATURATION VOLTAGE



BASE-EMITTER ON VOLTAGE



6

POWER TRANSISTOR

NPN SILICON

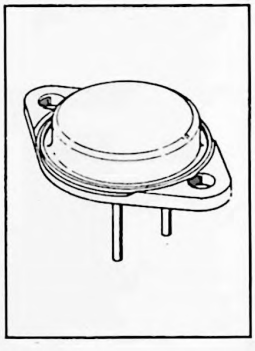
2N6249
2N6250
2N6251

POWER SWITCHING TRANSISTOR FOR APPLICATIONS IN INDUSTRIAL AND COMMERCIAL EQUIPMENT

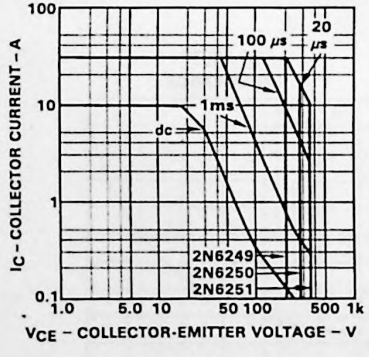
- 100 W DISSIPATION AT 25°C CASE
- 10 A MAXIMUM CONTINUOUS COLLECTOR CURRENT
- EXCELLENT IN LINE OPERATED INVERTER AND SWITCHING REGULATOR APPLICATIONS

ABSOLUTE MAXIMUM RATINGS (Note 1)

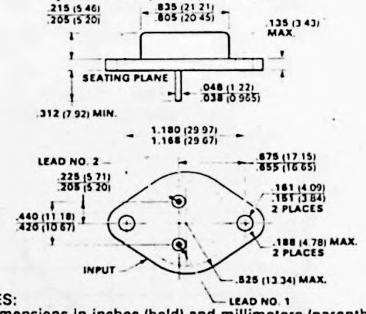
		2N6249	2N6250	2N6251
Maximum Voltages and Currents				
V_{CEO}	Collector to Emitter Voltage	200 V	275 V	350 V
V_{CBO}	Collector to Base Voltage	300 V	375 V	450 V
V_{EBO}	Emitter to Base Voltage	6.0 V	6.0 V	6.0 V
I_C	Continuous Collector Current	10 A	10 A	10 A
I_C	Peak Collector Current	30 A	30 A	30 A
I_B	Continuous Base Current	10 A	10 A	10 A
Maximum Power Dissipation				
P_D	Total Dissipation @ 25°C Case Temperature			175 W
	Derate Linearly from 25°C			1.0 W/°C
Maximum Temperatures				
T_J, T_{stg}	Storage and Operation Junction Temperatures			−65°C to +200°C
Thermal Characteristics				
$R_{\theta JC}$	Thermal Resistance, Junction to Case			1.0 °C/W



SAFE OPERATING AREA



JEDEC (TO-3) Outline



NOTES:
All dimensions in inches (bold) and millimeters (parentheses)
Pins are gold-plated or solder-dipped alloy 52
Pins 1 and 2 electrically isolated from case
Case is third electrical connection
Aluminum package with copper slug, pins are soldered in
Package weight is 7.4 grams
Aluminum cap

ELECTRICAL CHARACTERISTICS (25°C Case Temperature unless otherwise noted)

SYMBOL	CHARACTERISTIC	2N6249		2N6250		2N6251		UNIT	TEST CONDITIONS
		MIN	MAX	MIN	MAX	MIN	MAX		
OFF CHARACTERISTICS									
$V_{CEO(sus)}$	Collector-Emitter Sustaining Voltage (Note 1)	200		275		350		V	I_C = 200 mA, I_B = 0
$V_{CER(sus)}$	Collector-Emitter Sustaining Voltage (Note 1)	225		300		375		V	I_C = 200 mA, R_{BE} = 50 Ω
V_{EBO}	Emitter-Base Breakdown Voltage	6.0		6.0		6.0		V	I_E = 1.0 mA, I_C = 0
I_{CEO}	Collector Cutoff Current		5.0					mA	V_{CE} = 150 V, I_B = 0
					5.0			mA	V_{CE} = 225 V, I_B = 0
							5.0	mA	V_{CE} = 300 V, I_B = 0
I_{CEV}	Collector Cutoff Current		5.0					mA	V_{CE} = 225 V, V_{BE} = −1.5 V
					5.0			mA	V_{CE} = 300 V, V_{BE} = −1.5 V
							5.0	mA	V_{CE} = 375 V, V_{BE} = −1.5 V
			10					mA	V_{CE} = 225 V, V_{BE} = −1.5 V, T_C = 125°C
					10			mA	V_{CE} = 300 V, V_{BE} = −1.5 V, T_C = 125°C
							10	mA	V_{CE} = 375 V, V_{BE} = −1.5 V, T_C = 125°C
I_{EBO}	Emitter Cutoff Current		1.0		1.0		1.0	mA	V_{EB} = 6.0 V, I_C = 0
ON CHARACTERISTICS									
h_{FE}	DC Current Gain (Note 1)	10	50	8.0	50	6.0	50		I_C = 10 A, V_{CE} = 3.0 V
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage (Note 1)		1.5					V	I_C = 10 A, I_B = 1.0 A
					1.5			V	I_C = 10 A, I_B = 1.25 A
							1.5	V	I_C = 10 A, I_B = 1.67 A
$V_{BE(sat)}$	Base-Emitter Saturation Voltage (Note 1)		2.25					V	I_C = 10 A, I_B = 1.0 A
					2.25			V	I_C = 10 A, I_B = 1.25 A
							2.25	V	I_C = 10 A, I_B = 1.67 A
SECOND BREAKDOWN									
$I_{S/b}$	Second Breakdown Collector Current with base forward biased	5.8		5.8		5.8		A	t = 1.0 s (non repetitive), V_{CE} = 30 V
$E_{S/b}$	Second Breakdown Energy with base reversed biased	2.5		2.5		2.5		mJ	I_C = 10 A, $V_{BE(off)}$ = −4.0 V, L = 50 μh, R_B = 50 Ω
DYNAMIC CHARACTERISTICS									
h_{fe}	Magnitude of Common Emitter Small Signal Current Gain	2.5		2.5		2.5			I_C = 1.0 A, V_{CE} = 10 V, f = 1.0 MHz

NOTE: 1. Pulse conditions: Length = 300 μs, Duty Cycle = 2%.

6

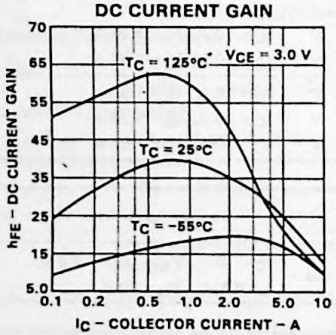
SWITCHING CHARACTERISTICS

RESISTIVE LOAD

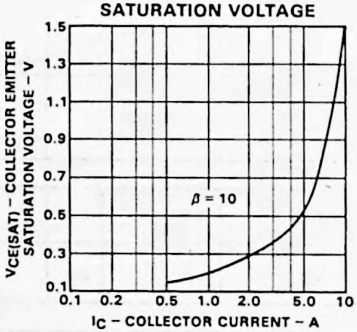
t_r	Rise Time		2.0					μs	V_{CC} = 200 V, I_C = 10 A, I_{B1} = 1.0 A, t_p = 20 μs, Duty Cycle = 500 Hz
t_s t_f	Storage Time Fall Time		3.5 1.0					μs μs	V_{CC} = 200 V, I_C = 10 A, I_{B1} = I_{B2} = 1.0 A, t_p = 20 μs, Duty Cycle = 500 Hz
t_r	Rise Time				2.0			μs	V_{CC} = 200 V, I_C = 10 A, I_{B1} = 1.25 A, t_p = 20 μs, Duty Cycle = 500 Hz
t_s t_f	Storage Time Fall Time				3.5 1.0			μs μs	V_{CC} = 200 V, I_C = 10 A, I_{B1} = I_{B2} = 1.25 A, t_p = 20 μs, Duty Cycle = 500 Hz
t_r	Rise Time						2.0	μs	V_{CC} = 200 V, I_C = 10 A, I_{B1} = 1.67 A, t_p = 20 μs, Duty Cycle = 500 Hz
t_s t_f	Storage Time Fall Time						3.5 1.0	μs μs	V_{CC} = 200 V, I_C = 10 A, I_{B1} = I_{B2} = 1.67 A, t_p = 20 μs, Duty Cycle = 500 Hz

TYPICAL ELECTRICAL CHARACTERISTICS

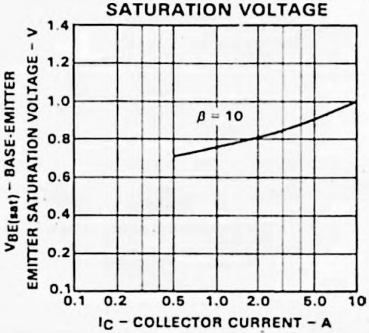
DC CURRENT GAIN



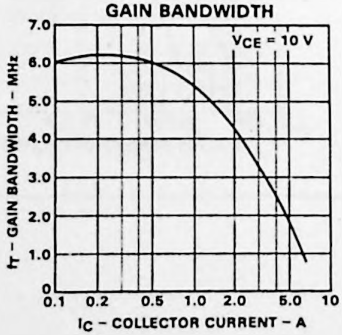
COLLECTOR-EMITTER SATURATION VOLTAGE



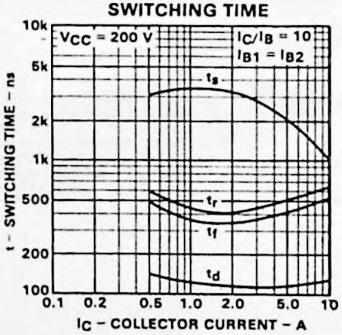
BASE-EMITTER SATURATION VOLTAGE



GAIN BANDWIDTH



SWITCHING TIME



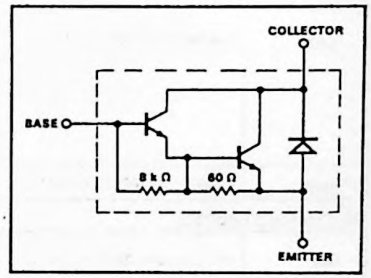
POWER DARLINGTON

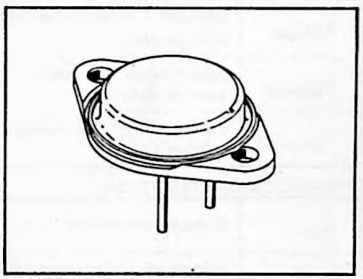
NPN SILICON

2N6282
2N6283
2N6284

DESIGNED FOR GENERAL PURPOSE AMPLIFIERS AND LOW SPEED SWITCHING APPLICATIONS

- 160 W DISSIPATION AT 25°C CASE
- 20 A MAXIMUM CONTINUOUS COLLECTOR CURRENT
- h_{FE} TYPICAL OF 3000 AT 10 A
- COMPLEMENT TO 2N6285, 2N6286, 2N6287





ABSOLUTE MAXIMUM RATINGS

		2N6282	2N6283	2N6284
Maximum Voltages and Currents				
V_{CE}	Collector to Emitter Voltage	60 V	80 V	100 V
V_{CB}	Collector to Base Voltage	60 V	80 V	100 V
V_{EB}	Emitter to Base Voltage	5.0 V	5.0 V	5.0 V
I_C	Continuous Collector Current	20 A	20 A	20 A
I_C	Peak Collector Current	40 A	40 A	40 A
I_B	Continuous Base Current	0.5 A	0.5 A	0.5 A
Maximum Power Dissipation				
P_D	Total Dissipation @ 25°C Case Temperature			160 W
	Derate Linearly from 25°C			0.92 W/°C
Maximum Temperatures				
T_J, T_{stg}	Storage and Operation Junction Temperatures			−65°C to +200°C
Thermal Characteristics				
$R_{\theta JC}$	Thermal Resistance, Junction to Case			1.09 °C/W

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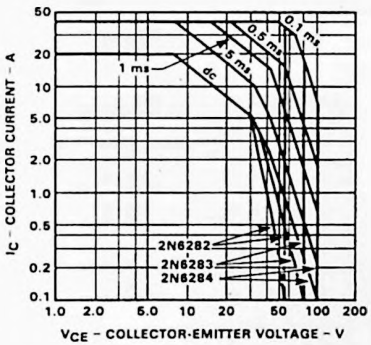
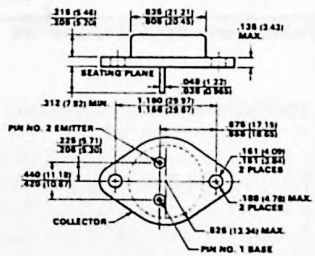
SAFE OPERATING AREA



JEDEC (TO-3) Outline



NOTES:
1. All dimensions in inches (bold) and millimeters (parentheses)
2. Pins are gold-plated or solder-dipped alloy 52
3. Pins 1 and 2 electrically isolated from case
4. Case is third electrical connection
5. Aluminum package with copper slug, pins are soldered in
6. Package weight is 7.4 grams
7. Aluminum cap

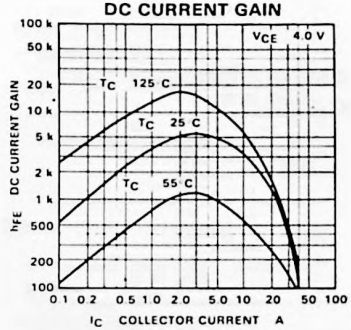
ELECTRICAL CHARACTERISTICS (25°C Case Temperature unless otherwise noted)

SYMBOL	CHARACTERISTIC	2N6282		2N6283		2N6284		UNITS	TEST CONDITIONS
		MIN	MAX	MIN	MAX	MIN	MAX		
OFF CHARACTERISTICS									
$V_{CEO(sus)}$	Collector-Emitter Sustaining Voltage (Note 1)	60		80		100		V	I_C = 100 mA, I_B = 0
I_{CEO}	Collector Cutoff Current		1.0					mA	V_{CE} = 30 V, I_B = 0
					1.0			mA	V_{CE} = 40 V, I_B = 0
							1.0	mA	V_{CE} = 50 V, I_B = 0
I_{CEX}	Collector Cutoff Current		0.5					mA	V_{CE} = 60 V, V_{BE} = −1.5 V
					0.5			mA	V_{CE} = 80 V, V_{BE} = −1.5 V
							0.5	mA	V_{CE} = 100 V, V_{BE} = −1.5 V
			5.0					mA	V_{CE} = 60 V, V_{BE} = −1.5 V, T_C = 150°C
					5.0			mA	V_{CE} = 80 V, V_{BE} = −1.5 V, T_C = 150°C
							5.0	mA	V_{CE} = 100 V, V_{BE} = −1.5 V, T_C = 150°C
I_{EBO}	Emitter Cutoff Current		2.0		2.0		2.0	mA	V_{EB} = 5.0 V, I_C = 0
ON CHARACTERISTICS									
h_{FE}	DC Current Gain (Note 1)	750	18 k	750	18 k	750	18 k		I_C = 10 A, V_{CE} = 3.0 V
		100		100		100			I_C = 30 A, V_{CE} = 3.0 V
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage (Note 1)		2.0		2.0		2.0	V	I_C = 10 A, I_B = 40 mA
			3.0		3.0		3.0	V	I_C = 20 A, I_B = 200 mA
$V_{BE(sat)}$	Base-Emitter Saturation Voltage (Note 1)		4.0		4.0		4.0	V	I_C = 20 A, I_B = 200 mA
$V_{BE(on)}$	Base-Emitter "On" Voltage (Note 1)		2.8		2.8		2.8	V	I_C = 10 A, V_{CE} = 3.0 V
DYNAMIC CHARACTERISTICS									
C_{ob}	Output Capacitance		400		400		400	pF	V_{CB} = 10 V, I_E = 0, f = 0.1 MHz
$\|h_{fe}\|$	Magnitude of Common Emitter Small Signal Current Gain	4.0		4.0		4.0			I_C = 10 A, V_{CE} = 3.0 V, f = 1.0 MHz
h_{fe}	Small Signal Current Gain	300		300		300			I_C = 10 A, V_{CE} = 3.0 V, f = 1.0 kHz

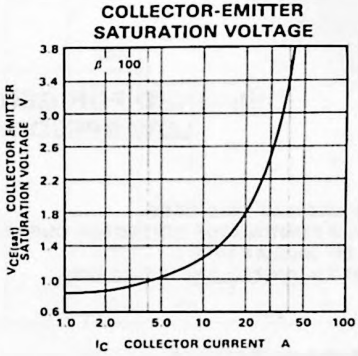
NOTE: 1. Pulse conditions: Length = 300 μs, Duty Cycle = 2%.

TYPICAL ELECTRICAL CHARACTERISTICS

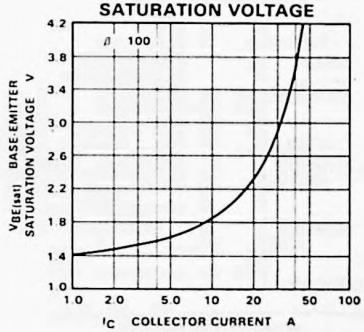
DC CURRENT GAIN



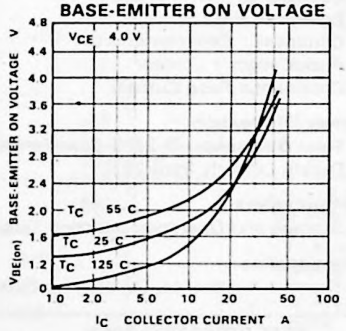
COLLECTOR-EMITTER SATURATION VOLTAGE



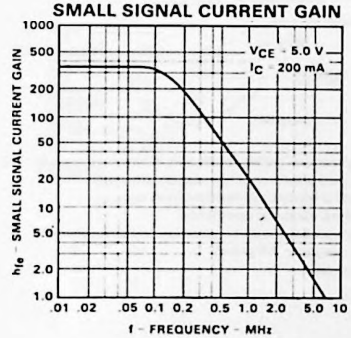
BASE-EMITTER SATURATION VOLTAGE



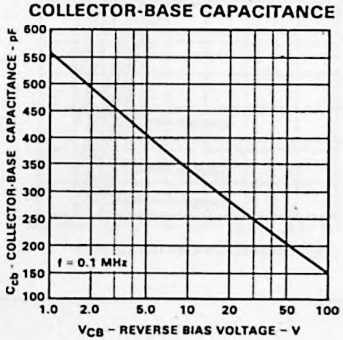
BASE-EMITTER ON VOLTAGE



SMALL SIGNAL CURRENT GAIN



COLLECTOR-BASE CAPACITANCE



6

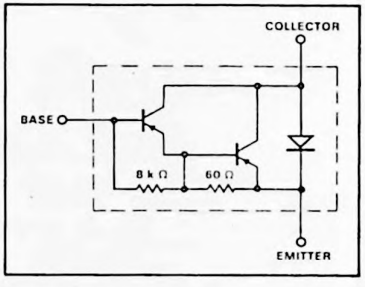
POWER DARLINGTON

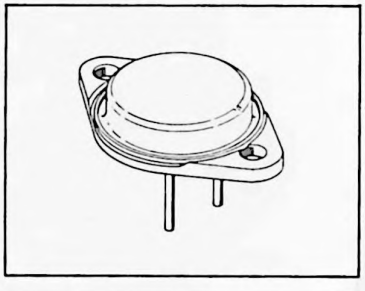
PNP SILICON

2N6285
2N6286
2N6287

DESIGNED FOR GENERAL PURPOSE AMPLIFIER AND LOW SPEED SWITCHING APPLICATIONS

- 160 W DISSIPATION AT 25°C CASE
- 20 A MAXIMUM CONTINUOUS COLLECTOR CURRENT
- h_{FE} TYPICAL OF 3000 AT 10 A
- COMPLEMENT TO 2N6282, 2N6283, 2N6284

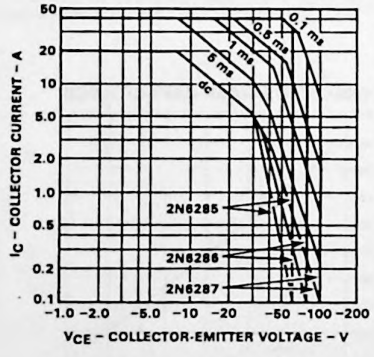




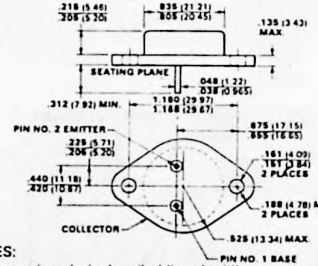
ABSOLUTE MAXIMUM RATINGS

		2N6285	2N6286	2N6287
Maximum Voltages and Currents				
V_{CE}	Collector to Emitter Voltage	−60 V	−80 V	−100 V
V_{CB}	Collector to Base Voltage	−60 V	−80 V	−100 V
V_{EB}	Emitter to Base Voltage	−5.0 V	−5.0 V	−5.0 V
I_C	Continuous Collector Current	20 A	20 A	20 A
I_C	Peak Collector Current	40 A	40 A	40 A
I_B	Continuous Base Current	0.5 A	0.5 A	0.5 A
Maximum Power Dissipation				
P_D	Total Dissipation @ 25°C Case Temperature			160 W
	Derate Linearly from 25°C			0.92 W/°C
Maximum Temperatures				
T_J, T_{stg}	Storage and Operation Junction Temperatures			−65°C to +200°C
Thermal Characteristics				
$R_{\theta JC}$	Thermal Resistance, Junction to Case			1.09°C/W

SAFE OPERATING AREA



JEDEC (TO-3) Outline



NOTES:
All dimensions in inches (bold) and millimeters (parentheses)
Pins are gold-plated or solder-dipped alloy 52
Pins 1 and 2 electrically isolated from case
Case is third electrical connection
Aluminum package with copper slug, pins are soldered in
Package weight is 7.4 grams
Aluminum cap

ELECTRICAL CHARACTERISTICS (25°C Case Temperature unless otherwise noted)

SYMBOL	CHARACTERISTIC	2N6285		2N6286		2N6287		UNITS	TEST CONDITIONS
		MIN	MAX	MIN	MAX	MIN	MAX		
OFF CHARACTERISTICS									
$V_{CEO(sus)}$	Collector-Emitter Sustaining Voltage (Note 1)	−60		−80		−100		V	I_C = 100 mA, I_B = 0
I_{CEO}	Collector Cutoff Current		1.0		1.0			mA	V_{CE} = −30 V, I_B = 0
								mA	V_{CE} = −40 V, I_B = 0
							1.0	mA	V_{CE} = −50 V, I_B = 0
I_{CEX}	Collector Cutoff Current		0.5		0.5			mA	V_{CE} = −60 V, V_{BE} = 1.5 V
								mA	V_{CE} = −80 V, V_{BE} = 1.5 V
							0.5	mA	V_{CE} = −100 V, V_{BE} = 1.5 V
			5.0					mA	V_{CE} = −60 V, V_{BE} = 1.5 V, T_C = 150°C
					5.0			mA	V_{CE} = −80 V, V_{BE} = 1.5 V, T_C = 150°C
							5.0	mA	V_{CE} = −100 V, V_{BE} = 1.5 V, T_C = 150°C
I_{EBO}	Emitter Cutoff Current		2.0		2.0		2.0	mA	V_{EB} = −5.0 V, I_C = 0
ON CHARACTERISTICS									
h_{FE}	DC Current Gain (Note 1)	750	18 k	750	18 k	750	18 k		I_C = 10 A, V_{CE} = −3.0 V
		100		100		100			I_C = 20 A, V_{CE} = −3.0 V
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage (Note 1)		−2.0		−2.0		−2.0	V	I_C = 10 A, I_B = 40 mA
			−3.0		−3.0		−3.0	V	I_C = 20 A, I_B = 200 mA
$V_{BE(sat)}$	Base-Emitter Saturation Voltage (Note 1)		−4.0		−4.0		−4.0	V	I_C = 20 A, I_B = 200 mA
$V_{BE(on)}$	Base-Emitter "On" Voltage (Note 1)		−2.8		−2.8		−2.8	V	I_C = 10 A, V_{CE} = −3.0 V
DYNAMIC CHARACTERISTICS									
C_{ob}	Output Capacitance		600		600		600	pF	V_{CB} = −10 V, I_E = 0, f = 0.1 MHz
$\lvert h_{fe} \rvert$	Magnitude of Common Emitter Small Signal Current Gain	4.0		4.0		4.0			I_C = 10 A, V_{CE} = −3.0 V, f = 1.0 MHz
h_{fe}	Small Signal Current Gain	300		300		300			I_C = 10 A, V_{CE} = −3.0 V, f = 1.0 kHz

NOTE: 1. Pulse conditions: Length = 300 μs, Duty Cycle = 2%.

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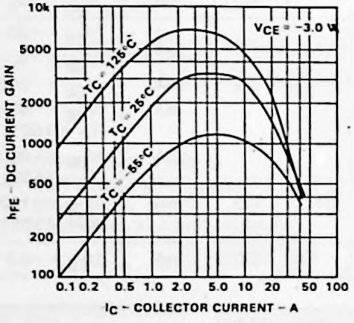
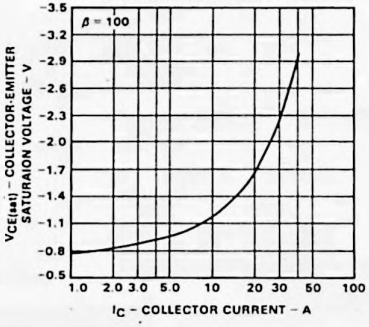
TYPICAL ELECTRICAL CHARACTERISTICS

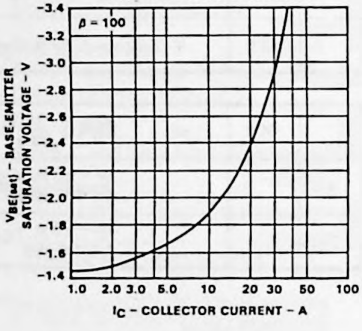
DC CURRENT GAIN



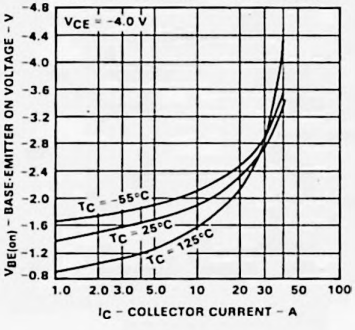
COLLECTOR-EMITTER SATURATION VOLTAGE



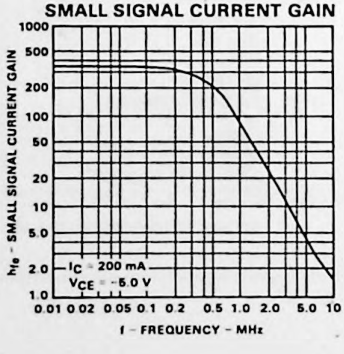
BASE-EMITTER SATURATION VOLTAGE



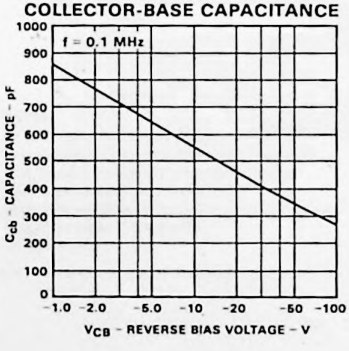
BASE-EMITTER ON VOLTAGE



SMALL SIGNAL CURRENT GAIN



COLLECTOR-BASE CAPACITANCE



POWER TRANSISTOR

NPN SILICON

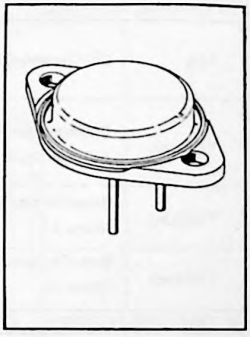
2N6306
2N6307M
2N6308M

POWER TRANSISTOR DESIGNED FOR HIGH VOLTAGE INVERTERS, SWITCHING REGULATORS AND LINE-OPERATED AMPLIFIER APPLICATIONS

- 125 W DISSIPATION AT 25°C CASE
- 8.0 A MAXIMUM CONTINUOUS COLLECTOR CURRENT

ABSOLUTE MAXIMUM RATINGS (Note 1)

		2N6306	2N6307M	2N6308M
Maximum Voltages and Currents				
V_{CEO}	Collector to Emitter Voltage	250 V	300 V	350 V
V_{CBO}	Collector to Base Voltage	500 V	450 V	500 V
V_{EBO}	Emitter to Base Voltage	8.0 V	8.0 V	8.0 V
I_C	Continuous Collector Current	8.0 A	8.0 A	8.0 A
I_C	Peak Collector Current	16 A	16 A	16 A
I_B	Continuous Base Current	4.0 A	4.0 A	4.0 A
Maximum Power Dissipation				
P_D	Total Dissipation @ 25°C Case Temperature			125 W
	Derate Linearly from 25°C			0.714 W/°C
Maximum Temperatures				
T_J, T_{stg}	Storage and Operation Junction Temperatures			−65°C to +200°C
Thermal Characteristics				
$R_{\theta JC}$	Thermal Resistance, Junction to Case			1.4°C/W
T_P	Maximum Pin Temperature (Soldering, 10s)			235°C



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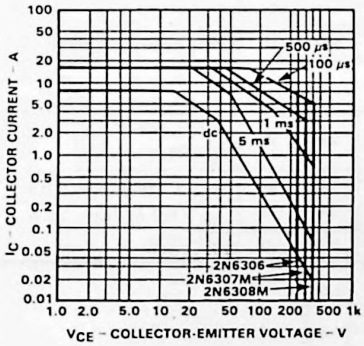
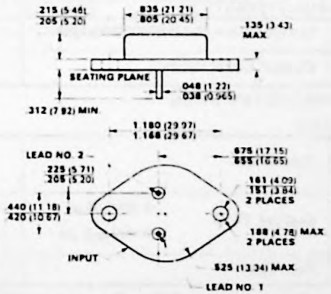
SAFE OPERATING AREA



JEDEC (TO-3) Outline



NOTES:
All dimensions in inches (bold) and millimeters (parentheses)
Pins are gold-plated or solder-dipped alloy 52
Pins 1 and 2 electrically isolated from case
Case is third electrical connection
Aluminum package with copper slug, pins are soldered in
Package weight is 7.4 grams
Aluminum cap

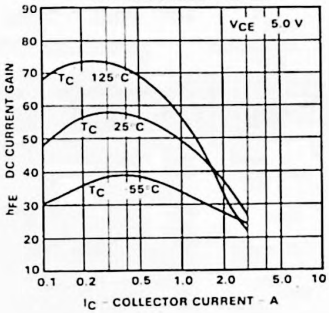
ELECTRICAL CHARACTERISTICS (25°C Case Temperature unless otherwise noted)

SYMBOL	CHARACTERISTIC	2N6306		2N6307M		2N6308M		UNIT	TEST CONDITIONS
		MIN	MAX	MIN	MAX	MIN	MAX		
OFF CHARACTERISTICS									
$V_{CEO(sus)}$	Collector-Emitter Sustaining Voltage (Note 1)	250		300		350		V	I_C = 100 mA, I_B = 0
I_{CEO}	Collector Cutoff Current		0.5		0.5		0.5	mA mA mA	V_{CE} = 250 V, I_B = 0 V_{CE} = 300 V, I_B = 0 V_{CE} = 350 V, I_B = 0
I_{CEX}	Collector Cutoff Current		0.5 2.5		0.5 2.5		0.5 2.5	mA mA mA mA mA mA	V_{CE} = 500 V, V_{BE} = −1.5 V V_{CE} = 450 V, V_{BE} = −1.5 V V_{CE} = 500 V, V_{BE} = −1.5 V V_{CE} = 450 V, V_{BE} = −1.5 V, T_C = 150°C V_{CE} = 450 V, V_{BE} = −1.5 V, T_C = 150°C V_{CE} = 500 V, V_{BE} = −1.5 V, T_C = 150°C
I_{EBO}	Emitter Cutoff Current		1.0		1.0		1.0	mA	V_{EB} = 8.0 V, I_C = 0
ON CHARACTERISTICS									
h_{FE}	DC Current Gain (Note 1)	15 4.0 TYP	75	15 4.0 TYP	75	12 3.0 TYP	60		I_C = 3.0 A, V_{CE} = 5.0 V I_C = 8.0 A, V_{CE} = 5.0 V
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage (Note 1)		0.8 5.0		1.0 5.0		1.5 5.0	V V V	I_C = 3.0 A, I_B = 0.6 A I_C = 8.0 A, I_B = 2.0 A I_C = 8.0 A, I_B = 2.67 A
$V_{BE(sat)}$	Base-Emitter Saturation Voltage (Note 1)		2.3		2.3		 2.5	V V	I_C = 8.0 A, I_B = 2.0 A I_C = 8.0 A, I_B = 2.67 A
$V_{BE(on)}$	Base-Emitter "On" Voltage (Note 1)		1.3		1.3		1.5	V	I_C = 3.0 A, V_{CE} = 5.0 V
SECOND BREAKDOWN									
$E_{S/b}$	Second Breakdown Energy with base reversed biased		180		180		180	mJ	I_C = 3.0 A, $V_{BE(off)}$ = −1.5 V, L = 40 mH, R_{BE} = 3.0 kΩ
DYNAMIC CHARACTERISTICS									
f_T	Current-Gain-Bandwidth Product	5.0		5.0		5.0		MHz	I_C = 0.3 A, V_{CE} = 10 V, f = 1.0 MHz
C_{ob}	Output Capacitance		250		250		250	pF	V_{CB} = 10 V, I_E = 0, f = 0.1 MHz
SWITCHING CHARACTERISTICS									
RESISTIVE LOAD									
t_r	Rise Time		0.6		0.6		0.6	μs	V_{CC} = 125 V, I_C = 3.0 A, I_{B1} = 0.6 A, t_p = 25 μs
t_s	Storage Time @ PW 25 μs @ PW 5.0 μs		1.6 0.8		1.6 0.8		1.6 0.8	μs μs	V_{CC} = 125 V, I_C = 3.0 A, I_{B1} = 0.6 A, I_{B2} = 1.5 A, t_p = 25 μs
t_f	Fall Time		0.4		0.4		0.4	μs	

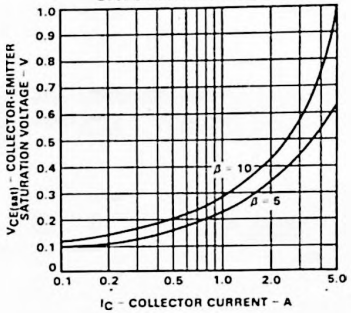
NOTE: 1. Pulse conditions: Length = 300 μs, Duty Cycle = 2%.

TYPICAL ELECTRICAL CHARACTERISTICS

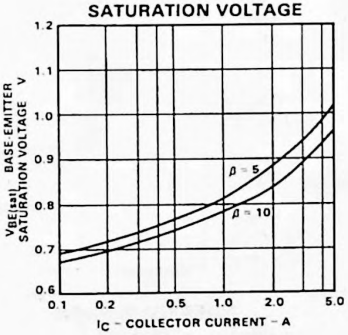
DC CURRENT GAIN



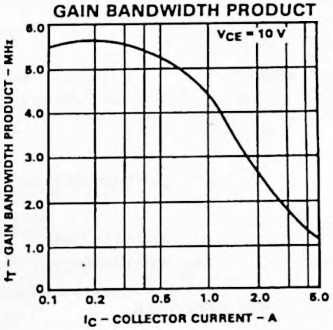
COLLECTOR-EMITTER SATURATION VOLTAGE



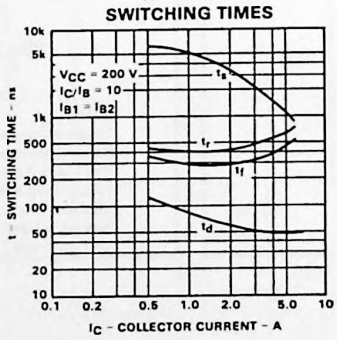
BASE-EMITTER SATURATION VOLTAGE



GAIN BANDWIDTH PRODUCT



SWITCHING TIMES



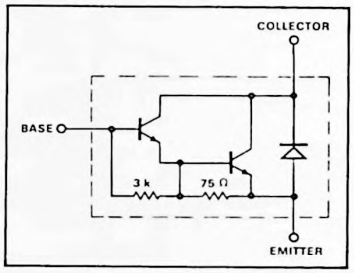
POWER DARLINGTON

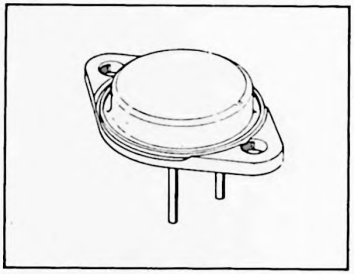
NPN SILICON

2N6383
2N6384
2N6385

A GENERAL PURPOSE DARLINGTON FOR USE IN POWER SWITCHING, HAMMER DRIVER AND SERIES AND SHUNT REGULATOR APPLICATIONS

- 100 W DISSIPATION AT 25°C CASE
- 10 A MAXIMUM CONTINUOUS COLLECTOR CURRENT
- GOOD SECOND BREAKDOWN CAPABILITY
- HIGH DC CURRENT GAIN

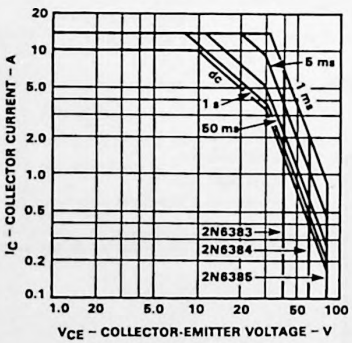




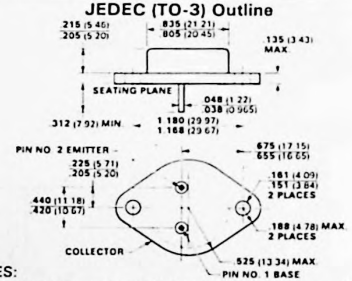
ABSOLUTE MAXIMUM RATINGS

		2N6383	2N6384	2N6385
Maximum Voltages and Currents				
V_{CE}	Collector to Emitter Voltage	40 V	60 V	80 V
V_{CB}	Collector to Base Voltage	40 V	60 V	80 V
V_{EB}	Emitter to Base Voltage	5.0 V	5.0 V	5.0 V
I_C	Continuous Collector Current	10 A	10 A	10 A
I_C	Peak Collector Current	15 A	15 A	15 A
I_B	Continuous Base Current	0.25 A	0.25 A	0.25 A
Maximum Power Dissipation				
P_D	Total Dissipation @ 25°C Case Temperature			100 W
	Derate Linearly from 25°C			0.57 W/°C
Maximum Temperatures				
T_J, T_{stg}	Storage and Operation Junction Temperatures			−65°C to +200°C
Thermal Characteristics				
$R_{\theta JC}$	Thermal Resistance, Junction to Case			1.75 °C/W
T_P	Maximum Pin Temperature (Soldering, 10 s)			235°C

SAFE OPERATING AREA



JEDEC (TO-3) Outline



NOTES:
All dimensions in inches (bold) and millimeters (parentheses)
Pins are gold-plated or solder-dipped alloy 52
Pins 1 and 2 electrically isolated from case
Case is third electrical connection
Aluminum package with copper slug, pins are soldered in
Package weight is 7.4 grams
Aluminum cap

ELECTRICAL CHARACTERISTICS (25°C Case Temperature unless otherwise noted)

SYMBOL	CHARACTERISTIC	2N6383		2N6384		2N6385		UNITS	TEST CONDITIONS
		MIN	MAX	MIN	MAX	MIN	MAX		
OFF CHARACTERISTICS									
$V_{CEO(sus)}$	Collector-Emitter Sustaining Voltage (Note 1)	40		60		80		V	I_C = 200 mA, I_B = 0
$V_{CER(susp}$	Collector-Emitter Sustaining Voltage (Note 1)	40		60		80		V	I_C = 200 mA, R_{BE} = 100 Ω
$V_{CEV(sus)}$	Collector-Emitter Sustaining Voltage (Note 1)	40		60		80		V	I_C = 200 mA, $V_{BE(off)}$ = −1.5 V
V_F	Parallel Diode Forward Voltage Drop		4.0		4.0		4.0	V	I_C = −10 A
I_{CEO}	Collector Cutoff Current		1.0					mA	V_{CE} = 40 V, I_B = 0
					1.0			mA	V_{CE} = 60 V, I_B = 0
							1.0	mA	V_{CE} = 80 V, I_B = 0
			10					mA	V_{CE} = 40 V, I_B = 0, T_C = 150°C
					10			mA	V_{CE} = 60 V, I_B = 0, T_C = 150°C
							10	mA	V_{CE} = 80 V, I_B = 0, T_C = 150°C
I_{CEV}	Collector Cutoff Current		0.3					mA	V_{CE} = 40 V, V_{BE} = −1.5 V
					0.3			mA	V_{CE} = 60 V, V_{BE} = −1.5 V
							0.3	mA	V_{CE} = 80 V, V_{BE} = −1.5 V
			3.0					mA	V_{CE} = 40 V, V_{BE} = −1.5 V, T_C = 150°C
					3.0			mA	V_{CE} = 60 V, V_{BE} = −1.5 V, T_C = 150°C
							3.0	mA	V_{CE} = 80 V, V_{BE} = −1.5 V, T_C = 150°C
I_{EBO}	Emitter Cutoff Current		5.0		5.0		5.0	mA	V_{EB} = 5.0 V, I_C = 0
ON CHARACTERISTICS									
h_{FE}	DC Current Gain (Note 1)	1 k	20 k	1 k	20 k	1 k	20 k		I_C = 5.0 A, V_{CE} = 3.0 V
		100		100		100			I_C = 10 A, V_{CE} = 3.0 V
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage (Note 1)		2.0		2.0		2.0	V	I_C = 5.0 A, I_B = 10 mA
			3.0		3.0		3.0	V	I_C = 10 A, I_B = 100 mA
$V_{BE(on)}$	Base-Emitter "On" Voltage (Note 1)		2.8		2.8		2.8	V	I_C = 5.0 A, V_{CE} = 3.0 V
			4.5		4.5		4.5	V	I_C = 10 A, V_{CE} = 3.0 V
SECOND BREAKDOWN									
$I_{S/b}$	Second Breakdown Collector Current with Base Forward Biased	2.85						A	V_{CE} = 35 V t = 1.0 s (non repetitive)
				0.62				A	V_{CE} = 55 V t = 1.0 s (non repetitive)
						0.22		A	V_{CE} = 75 V t = 1.0 s (non repetitive)
$E_{S/b}$	Second Breakdown Energy with Base Reversed Biased	120		120		120		mj	I_C = 4.5 A, $V_{BE(off)}$ = −1.5 V, L = 12 mH
DYNAMIC CHARACTERISTICS									
C_{ob}	Output Capacitance		200		200		200	pF	V_{CB} = 10 V, I_E = 0, f = 0.1 MHz
$\|h_{fe}\|$	Magnitude of Common Emitter Small Signal Short Circuit Forward Current Transfer Ratio	20		20		20			I_C = 1.0 A, V_{CE} = 5.0 V, f = 1.0 MHz
h_{fe}	Small Signal Current Gain	1 k		1 k		1 k			I_C = 1.0 A, V_{CE} = 5.0 V, f = 1.0 kHz

NOTE: 1. Pulse conditions: Length = 300 μs, Duty Cycle = 2%.

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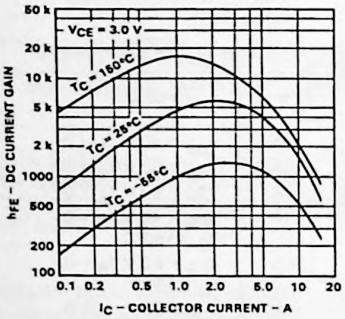
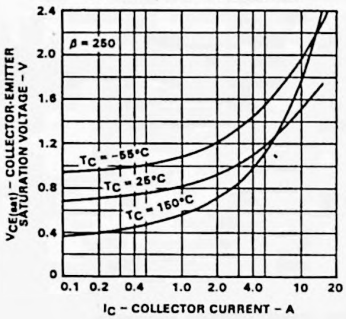
TYPICAL ELECTRICAL CHARACTERISTICS

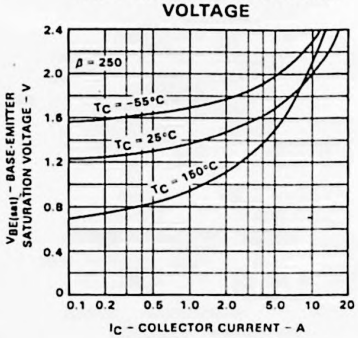
DC CURRENT GAIN



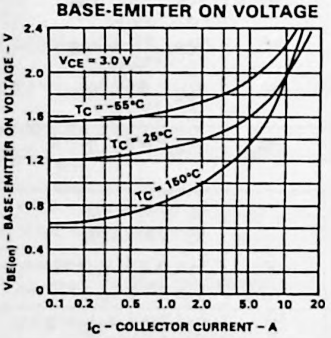
COLLECTOR-EMITTER SATURATION VOLTAGE



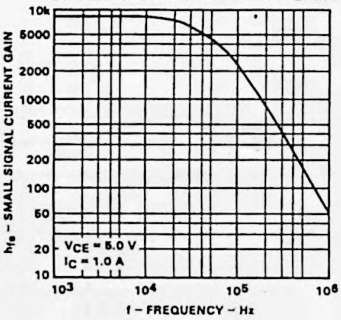
BASE-EMITTER SATURATION VOLTAGE



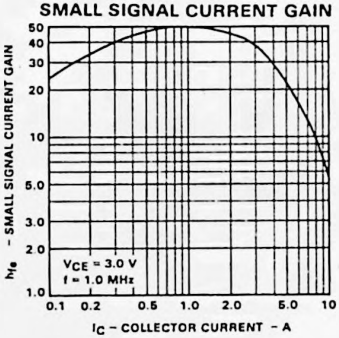
BASE-EMITTER ON VOLTAGE



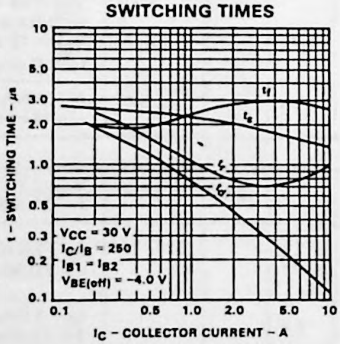
SMALL SIGNAL CURRENT GAIN



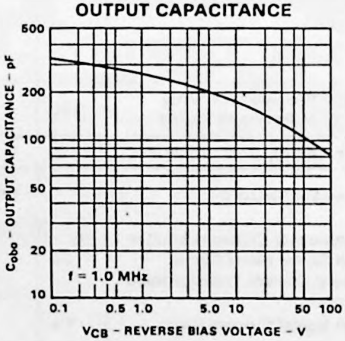
SMALL SIGNAL CURRENT GAIN



SWITCHING TIMES



OUTPUT CAPACITANCE



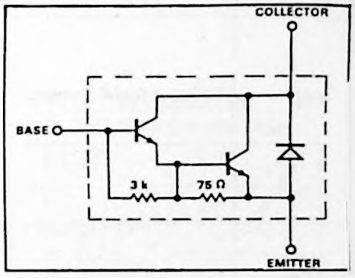
POWER DARLINGTON

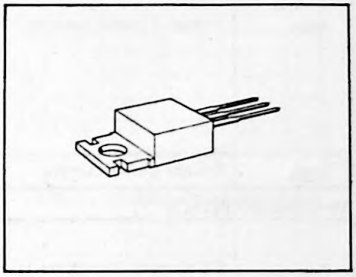
NPN SILICON

2N6386
2N6387
2N6388

DESIGNED FOR USE IN POWER SWITCHING, HAMMER DRIVER AND SERIES AND SHUNT REGULATOR APPLICATIONS

- 40 W DISSIPATION AT 25°C CASE
- 10 A MAXIMUM CONTINUOUS COLLECTOR CURRENT
- GOOD SECOND BREAKDOWN CAPABILITY
- HIGH DC CURRENT GAIN

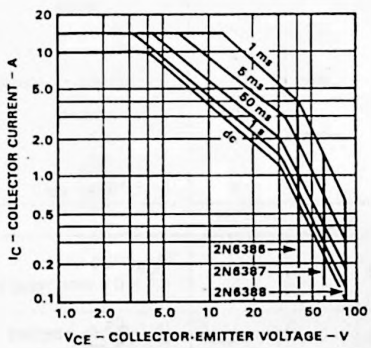




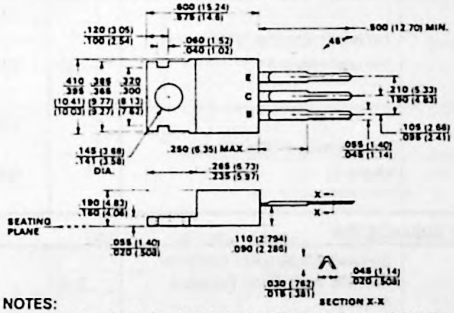
ABSOLUTE MAXIMUM RATINGS

		2N6386	2N6387	2N6388
Maximum Voltages and Currents				
V_{CE}	Collector to Emitter Voltage	40 V	60 V	80 V
V_{CB}	Collector to Base Voltage	40 V	60 V	80 V
V_{EB}	Emitter to Base Voltage	5.0 V	5.0 V	5.0 V
I_C	Continuous Collector Current	10 A	10 A	10 A
I_C	Peak Collector Current	15 A	15 A	15 A
I_B	Continuous Base Current	0.25 A	0.25 A	0.25 A
Maximum Power Dissipation				
P_D	Total Dissipation @ 25°C Case Temperature			40 W
	Derate Linearly from 25°C			0.32 W/°C
Maximum Temperatures				
T_J, T_{stg}	Storage and Operation Junction Temperatures			−65°C to +150°C
Thermal Characteristics				
$R_{\theta JC}$	Thermal Resistance, Junction to Case			3.1 °C/W
T_P	Maximum Pin Temperature (Soldering, 5 s)			235°C

SAFE OPERATING AREA



JEDEC (TO-220) Outline*



NOTES:
All dimensions in inches (bold) and millimeters (parentheses)
Package is silicone plastic with nickel-plated copper tab and pins
Center pin is electrical contact with the mounting tab
Package weight is 2.1 grams
*Available in various pin configurations

ELECTRICAL CHARACTERISTICS (25°C Case Temperature unless otherwise noted)

SYMBOL	CHARACTERISTIC	2N6386		2N6387		2N6388		UNITS	TEST CONDITIONS
		MIN	MAX	MIN	MAX	MIN	MAX		
OFF CHARACTERISTICS									
$V_{CEO(sus)}$	Collector-Emitter Sustaining Voltage (Note 1)	40		60		80		V	I_C = 200 mA, I_B = 0
$V_{CER(sus)}$	Collector-Emitter Sustaining Voltage (Note 1)	40		60		80		V	I_C = 200 mA, R_{BE} = 100 Ω
$V_{CEV(sus)}$	Collector-Emitter Sustaining Voltage (Note 1)	40		60		80		V	I_C = 200 mA, $V_{BE(off)}$ = −1.5 V
V_F	Parallel Diode Forward Voltage Drop		4.0					V	I_C = −8.0 A
					4.0		4.0	V	I_C = −10 A
I_{CEO}	Collector Cutoff Current		1.0					mA	V_{CE} = 40 V, I_B = 0
					1.0			mA	V_{CE} = 60 V, I_B = 0
							1.0	mA	V_{CE} = 80 V, I_B = 0
			10					mA	V_{CE} = 40 V, I_B = 0, T_C = 150°C
					10			mA	V_{CE} = 60 V, I_B = 0, T_C = 150°C
							10	mA	V_{CE} = 80 V, I_B = 0, T_C = 150°C
I_{CEV}	Collector Cutoff Current		0.3					mA	V_{CE} = 40 V, V_{BE} = −1.5 V
					0.3			mA	V_{CE} = 60 V, V_{BE} = −1.5 V
							0.3	mA	V_{CE} = 80 V, V_{BE} = −1.5 V
			3.0					mA	V_{CE} = 40 V, V_{BE} = −1.5 V, T_C = 150°C
					3.0			mA	V_{CE} = 60 V, V_{BE} = −1.5 V, T_C = 150°C
							3.0	mA	V_{CE} = 80 V, V_{BE} = −1.5 V, T_C = 150°C
I_{EBO}	Emitter Cutoff Current		5.0		5.0		5.0	mA	V_{EB} = 5.0 V, I_C = 0
ON CHARACTERISTICS									
h_{FE}	DC Current Gain (Note 1)	1 k	20 k						I_C = 3.0 A, V_{CE} = 3.0 V
				1 k	20 k	1 k	20 k		I_C = 5.0 A, V_C = 3.0 V
		100							I_C = 8.0 A, V_{CE} = 3.0 V
				100		100			I_C = 10 A, V_{CE} = 3.0 V
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage (Note 1)		2.0					V	I_C = 3.0 A, I_B = 6.0 mA
					2.0		2.0	V	I_C = 5.0 A, I_B = 10 mA
			3.0					V	I_C = 8.0 A, I_B = 80 mA
					3.0		3.0	V	I_C = 10 A, I_B = 100 mA
$V_{BE(on)}$	Base-Emitter "On" Voltage (Note 1)		2.8					V	I_C = 3.0 A, V_{CE} = 3.0 V
					2.8		2.8	V	I_C = 5.0 A, V_{CE} = 3.0 V
			4.5					V	I_C = 8.0 A, V_{CE} = 3.0 V
					4.5		4.5	V	I_C = 10 A, V_{CE} = 3.0 V
SECOND BREAKDOWN									
$I_{S/b}$	Second Breakdown Collector Current with Base Forward Biased	1.2		1.2		1.2		A	V_{CE} = 35 V, t = 1.0 s (non repetitive)
$E_{S/b}$	Second Breakdown Energy with Base Reversed Biased	120		120		120		mj	I_C = 4.5 A, $V_{BE(off)}$ = −1.5 V, L = 12 mH

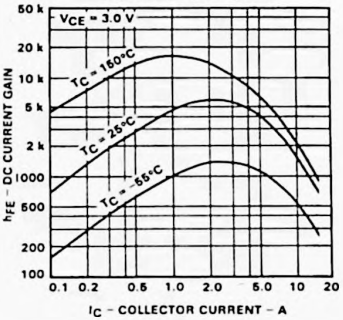
ELECTRICAL CHARACTERISTICS (25°C Case Temperature unless otherwise noted) (Cont'd)

SYMBOL	CHARACTERISTIC	2N6386		2N6387		2N6388		UNITS	TEST CONDITIONS
		MIN	MAX	MIN	MAX	MIN	MAX		
DYNAMIC CHARACTERISTICS									
C_{ob}	Output Capacitance		200		200		200	pF	V_{CB} = 10 V, I_E = 0, f = 0.1 MHz
$\|h_{fe}\|$	Magnitude of Common Emitter Small Signal Short Circuit Forward Current Transfer Ratio	20		20		20			I_C = 1.0 A, V_{CE} = 5.0 V, f = 1.0 MHz
h_{fe}	Small Signal Current Gain	1 k		1 k		1 k			I_C = 1.0 A, V_{CE} = 5.0 V, f = 1.0 kHz

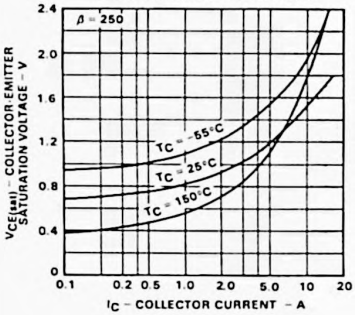
NOTE: 1. Pulse conditions: Length = 300 μs, Duty Cycle = 2%.

TYPICAL ELECTRICAL CHARACTERISTICS

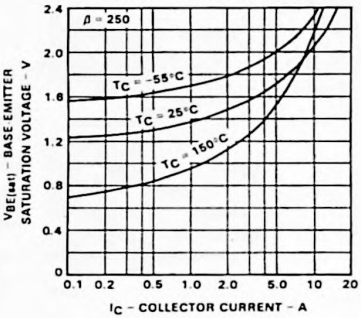
DC CURRENT GAIN



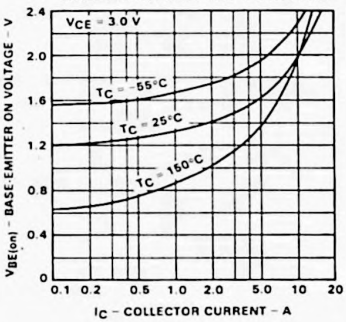
COLLECTOR-EMITTER SATURATION VOLTAGE



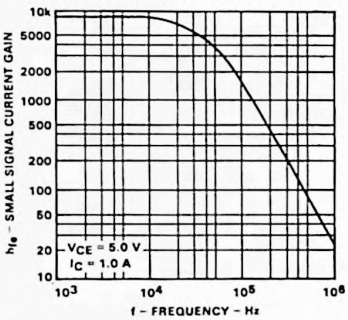
BASE-EMITTER SATURATION VOLTAGE



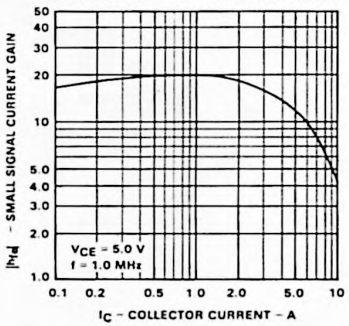
BASE-EMITTER ON VOLTAGE



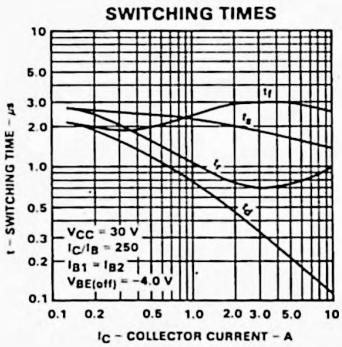
SMALL SIGNAL CURRENT GAIN



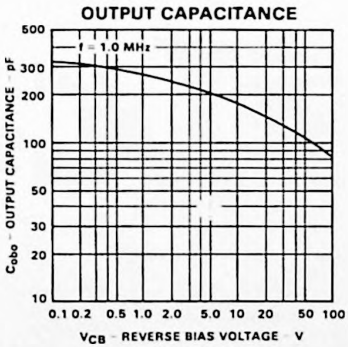
SMALL SIGNAL CURRENT GAIN



SWITCHING TIMES



OUTPUT CAPACITANCE



POWER TRANSISTOR

NPN SILICON

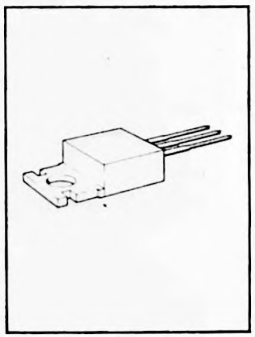
2N6473
2N6474

GENERAL PURPOSE MEDIUM POWER TRANSISTORS FOR SWITCHING AND AMPLIFIER APPLICATIONS

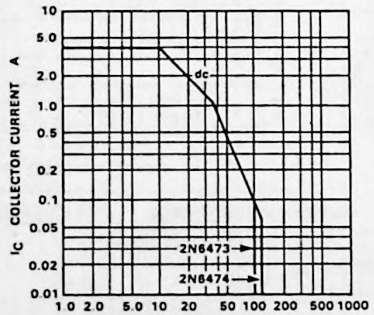
- 40 W DISSIPATION AT 25°C CASE
- 4 A MAXIMUM CONTINUOUS COLLECTOR CURRENT
- LOW SATURATION VOLTAGES
- COMPLEMENTS TO 2N6475, 2N6476

ABSOLUTE MAXIMUM RATINGS (Note 1)

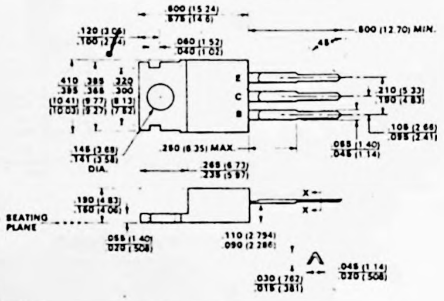
		2N6473	2N6474
Maximum Voltages and Currents			
V_{CEO}	Collector to Emitter Voltage	100 V	120 V
V_{CBO}	Collector to Base Voltage	110 V	130 V
V_{EBO}	Emitter to Base Voltage	5.0 V	5.0 V
I_C	Continuous Collector Current (≤106°C Case)	4.0 A	4.0 A
I_B	Continuous Base Current (≤130°C Case)	2.0 A	2.0 A
Maximum Power Dissipation			
P_D	Total Dissipation @ 25°C Case Temperature		40 W
	Derate Linearly from 25°C		0.32 W/°C
Maximum Temperatures			
T_J, T_{stg}	Storage and Operation Junction Temperatures		−65°C to +150°C
Thermal Characteristics			
$R_{\theta JC}$	Thermal Resistance, Junction to Case		3.125°C/W
T_P	Maximum Pin Temperature (Soldering, 10 s)		235°C



SAFE OPERATING AREA



JEDEC (TO-220) Outline**



NOTES:
All dimensions in inches (bold) and millimeters (parentheses)
Package is silicone plastic with nickel-plated copper tab and pins
*Mechanically interchangeable with TO-66
Center pin is electrical contact with the mounting tab
Package weight is 2.1 grams
**Available in various pin configurations

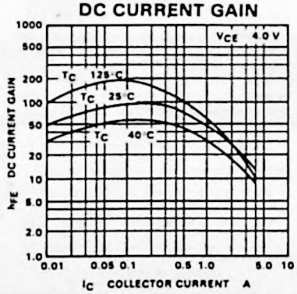
ELECTRICAL CHARACTERISTICS (25°C Case Temperature unless otherwise noted)

SYMBOL	CHARACTERISTIC	2N6473		2N6474		UNIT	TEST CONDITIONS
		MIN	MAX	MIN	MAX		
OFF CHARACTERISTICS							
$V_{CEO(sus)}$	Collector-Emitter Sustaining Voltage (Note 1)	100		120		V	I_C = 100 mA, I_B = 0
$V_{CER(sus)}$	Collector-Emitter Sustaining Voltage (Note 1)	110		130		V	I_C = 100 mA, R_{BE} = 100 Ω
I_{CEO}	Collector Cutoff Current		1.0			mA	V_{CE} = 50 V, I_B = 0
					1.0	mA	V_{CE} = 60 V, I_B = 0
I_{CEX}	Collector Cutoff Current		0.1			mA	V_{CE} = 100 V, V_{BE} = −1.5 V
					0.1	mA	V_{CE} = 120 V, V_{BE} = −1.5 V
			2.0			mA	V_{CE} = 100 V, V_{BE} = −1.5 V, T_C = 100°C
					2.0	mA	V_{CE} = 120 V, V_{BE} = −1.5 V, T_C = 100°C
I_{CER}	Collector Cutoff Current		0.1			mA	V_{CE} = 100 V, R_{BE} = 100 Ω
					0.1	mA	V_{CE} = 120 V, R_{BE} = 100 Ω
			2.0			mA	V_{CE} = 100 V, R_{BE} = 100 Ω T_C = 100°C
					2.0	mA	V_{CE} = 120 V, R_{BE} = 100 Ω T_C = 100°C
I_{EBO}	Emitter Cutoff Current		1.0		1.0	mA	V_{EB} = 5.0 V, I_C = 0
ON CHARACTERISTICS							
h_{FE}	DC Current Gain (Note 1)	15	150	15	150		I_C = 1.5 A, V_{CE} = 4.0 V
		2.0		2.0			I_C = 4.0 A, V_{CE} = 2.5 V
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage (Note 1)		1.2		1.2	V	I_C = 1.5 A, I_B = 0.15 A
			2.5		2.5	V	I_C = 4.0 A, I_B = 2.0 A
$V_{BE(on)}$	Base-Emitter "On" Voltage (Note 1)		2.0		2.0	V	I_C = 1.5 A, V_{CE} = 4.0 V
			3.5		3.5	V	I_C = 4.0 A, V_{CE} = 2.5 V
DYNAMIC CHARACTERISTICS							
f_T	Current-Gain-Bandwidth Product	4.0		4.0		MHz	I_C = 0.5 A, V_{CE} = 4.0 V
C_{ob}	Output Capacitance		250		250	pF	V_{CB} = 10 V, I_E = 0, f = 1.0 MHz
$\|h_{fe}\|$	Magnitude of Common Emitter Small Signal Current Gain	4.0		4.0			I_C = 0.5 A, V_{CE} = 4.0 V, f = 1.0 MHz
h_{fe}	Small Signal Current Gain	20		20			I_C = 0.5 A, V_{CE} = 4.0 V, f = 50 kHz

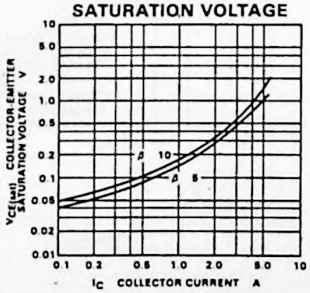
NOTE: 1. Pulse conditions: Length = 300 μs, Duty Cycle = 2%.

TYPICAL ELECTRICAL CHARACTERISTICS

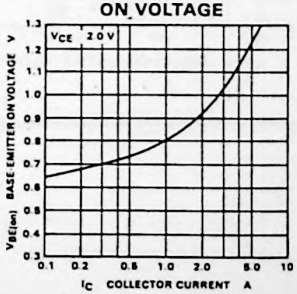
DC CURRENT GAIN



COLLECTOR-EMITTER SATURATION VOLTAGE



BASE-EMITTER ON VOLTAGE



POWER TRANSISTOR

PNP SILCON

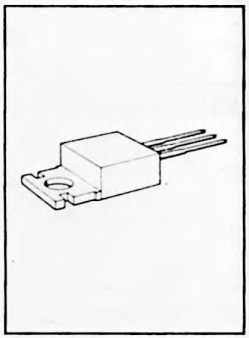
2N6475
2N6476

GENERAL PURPOSE MEDIUM-POWER TRANSISTORS FOR SWITCHING AND AMPLIFIER APPLICATIONS

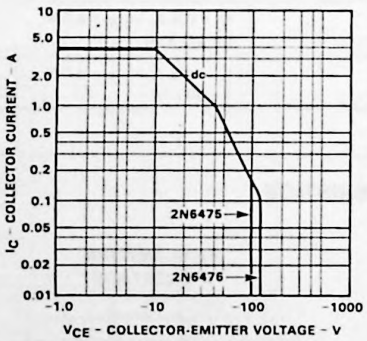
- 40 W DISSIPATION AT 25°C CASE
- 4.0 A MAZIMUM CONTINUOUS COLLECTOR CURRENT
- LOW SATURATION VOLTAGES
- COMPLEMENT TO 2N6473, 2N6474

ABSOLUTE MAXIMUM RATINGS

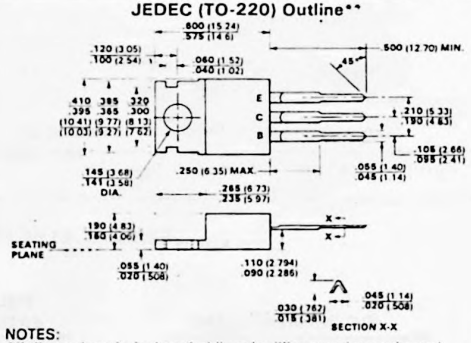
		2N6475	2N6476
Maximum Voltages and Currents			
V_{CE}	Collector to Emitter Voltage	−100 V	−120 V
V_{CB}	Collector to Base Voltage	−110 V	−130 V
V_{EB}	Emitter to Base Voltage	−5.0 V	−5.0 V
I_C	Continuous Collector Current (≤ 106°C Case)	4.0 A	4.0 A
I_B	Continuous Base Current (≤ 130°C Case)	2.0 A	2.0 A
Maximum Power Dissipation			
P_D	Total Dissipation @ 25°C Case Temperature		40 W
	Derate Linearly from 25°C		0.32 W/°C
Maximum Temperatures			
T_J, T_{stg}	Storage and Operation Junction Temperatures		−65°C to +150°C
Thermal Characteristics			
$R_{\theta JC}$	Thermal Resistance, Junction to Case		3.125°C/W
T_P	Maximum Pin Temperature (Soldering, 10 s)		235°C



SAFE OPERATING AREA



JEDEC (TO-220) Outline**



NOTES:
All dimensions in inches (bold) and millimeters (parentheses)
Package is silicone plastic with nickel-plated copper tab and pins
*Mechanically interchangeable with TO-66
Center pin is electrical contact with the mounting tab
Package weight is 2.1 grams
**Available in various pin configurations

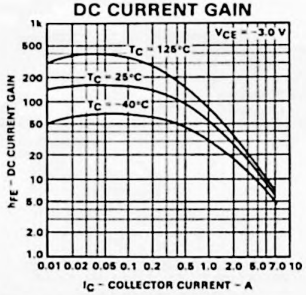
ELECTRICAL CHARACTERISTICS (25°C Case Temperature unless otherwise noted)

SYMBOL	CHARACTERISTICS	2N6475 MIN	2N6475 MAX	2N6476 MIN	2N6476 MAX	UNIT	TEST CONDITIONS
OFF CHARACTERISTICS							
$V_{CEO(sus)}$	Collector-Emitter Sustaining Voltage (Note 1)	−100		−120		V	I_C = 100 mA, I_B = 0
$V_{CER(sus)}$	Collector-Emitter Sustaining Voltage (Note 1)	−110		−130		V	I_C = 100 mA, R_{BE} = 100 Ω
I_{CEO}	Collector Cutoff Current		1.0			mA	V_{CE} = −50 V, I_B = 0
					1.0	mA	V_{CE} = −60 V, I_B = 0
I_{CEX}	Collector Cutoff Current		0.1			mA	V_{CE} = −100 V, V_{BE} = 1.5 V
					0.1	mA	V_{CE} = −120 V, V_{BE} = 1.5 V
			2.0			mA	V_{CE} = −100 V, V_{BE} = 1.5 V, T_C = 100°C
					2.0	mA	V_{CE} = −120 V, V_{BE} = 1.5 V, T_C = 100°C
I_{CER}	Collector Cutoff Current		0.1			mA	V_{CE} = −100 V, R_{BE} = 100 Ω
					0.1	mA	V_{CE} = −120 V, R_{BE} = 100 Ω
			2.0			mA	V_{CE} = −100 V, R_{BE} = 100 Ω, T_C = 100°C
					2.0	mA	V_{CE} = −120 V, R_{BE} = 100 Ω, T_C = 100°C
I_{EBO}	Emitter Cutoff Current		1.0		1.0	mA	V_{EB} = −5.0 V, I_C = 0
ON CHARACTERISTICS							
h_{FE}	DC Current Gain (Note 1)	15	150	15	150		I_C = 1.5 A, V_{CE} = −4.0 V
		2.0		2.0			I_C = 4.0 A, V_{CE} = −2.5 V
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage (Note 1)		−1.2		−1.2	V	I_C = 1.5 A, I_B = 0.15 A
			−2.5		−2.5	V	I_C = 4.0 A, I_B = 2.0 A
$V_{BE(on)}$	Base-Emitter "On" Voltage (Note 1)		−2.0		−2.0	V	I_C = 1.5 A, V_{CE} = −4.0 V
			−3.5		−3.5	V	I_C = 4.0 A, V_{CE} = −2.5 V
DYNAMIC CHARACTERISTICS							
f_T	Current Gain Bandwidth Product	10		10		MHz	I_C = 0.5 A, V_{CE} = −4.0 V
C_{ob}	Output Capacitance		250		250	pF	V_{CB} = −10 V, I_E = 0, f = 1.0 MHz
$\lvert h_{fe} \rvert$	Magnitude of Common Emitter Small Signal Current Gain	10		10			I_C = 0.5 A, V_{CE} = −4.0 V, f = 1.0 MHz
h_{fe}	Small Signal Current Gain	20		20			I_C = 0.5 A, V_{CE} = −4.0 V, f = 1.0 kHz

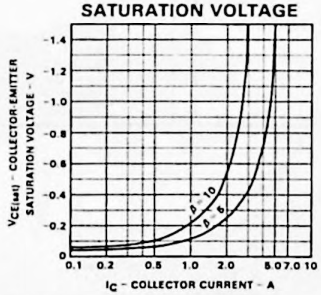
NOTE: 1. Pulse conditions: Length = 300 μs, Duty Cycle = 2%.

TYPICAL ELECTRICAL CHARACTERISTICS

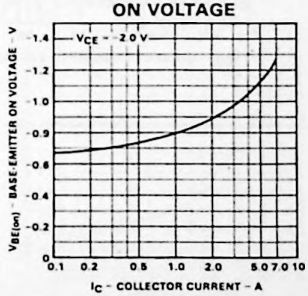
DC CURRENT GAIN



COLLECTOR-EMITTER SATURATION VOLTAGE



BASE-EMITTER ON VOLTAGE



POWER TRANSISTOR

NPN SILICON

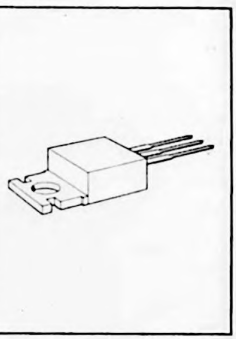
2N6486
2N6487
2N6488

GENERAL PURPOSE TRANSISTORS DESIGNED FOR MEDIUM POWER SWITCHING AND AMPLIFIER APPLICATIONS

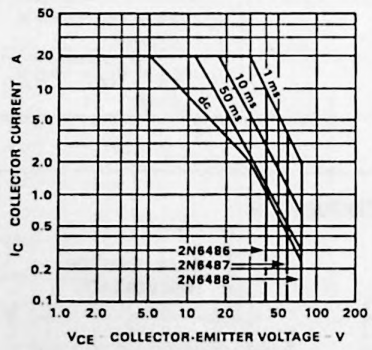
- 75 W DISSIPATION AT 25°C CASE
- 15 A MAXIMUM CONTINUOUS COLLECTOR CURRENT
- COMPLEMENT TO 2N6489, 2N6490, 2N6491

ABSOLUTE MAXIMUM RATINGS (Note 1)

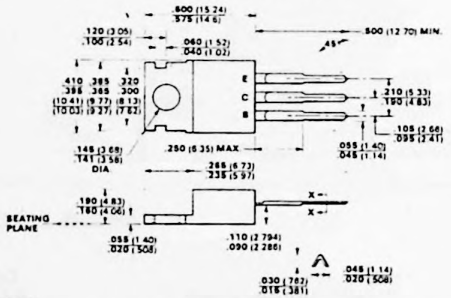
		2N6486	2N6487	2N6488
Maximum Voltages and Currents				
V_{CEO}	Collector to Emitter Voltage	40 V	60 V	80 V
V_{CBO}	Collector to Base Voltage	50 V	70 V	90 V
V_{EBO}	Emitter to Base Voltage	5.0 V	5.0 V	5.0 V
I_C	Continuous Collector Current	15 A	15 A	15 A
I_B	Continuous Base Current	5.0 A	5.0 A	5.0 A
Maximum Power Dissipation				
P_D	Total Dissipation @ 25°C Case Temperature			75 W
	Derate Linearly from 25°C			0.6 W/°C
Maximum Temperatures				
T_J, T_{stg}	Storage and Operation Junction Temperatures			−65°C to +150°C
Thermal Characteristics				
$R_{\theta JC}$	Thermal Resistance, Junction to Case			1.67°C/W
T_P	Maximum Pin Temperature (Soldering, 10 s)			235°C



SAFE OPERATING AREA



JEDEC (TO-220) Outline**



NOTES:
All dimensions in inches (bold) and millimeters (parentheses)
Package is silicone plastic with nickel-plated copper tab and pins
*Mechanically interchangeable with TO-66
Center pin is electrical contact with the mounting tab
Package weight is 2.1 grams
**Available in various pin configurations

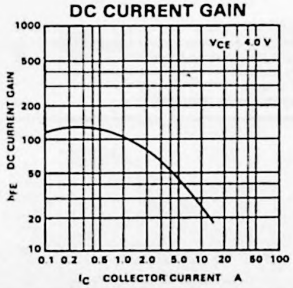
ELECTRICAL CHARACTERISTICS (25°C Case Temperature unless otherwise noted)

SYMBOL	CHARACTERISTIC	2N6486		2N6487		2N6488		UNIT	TEST CONDITIONS
		MIN	MAX	MIN	MAX	MIN	MAX		
OFF CHARACTERISTICS									
$V_{CEO(sus)}$	Collector-Emitter Sustaining Voltage (Note 1)	40		60		80		V	I_C = 200 mA, I_B = 0
$V_{CER(sus)}$	Collector-Emitter Sustaining Voltage (Note 1)	45		65		85		V	I_C = 200 mA, R_{BE} = 100 Ω
$V_{CEX(sus)}$	Collector-Emitter Sustaining Voltage (Note 1)	50		70		90		V	I_C = 200 mA, $V_{BE(off)}$ = −1.5 V
I_{CEO}	Collector Cutoff Current		1.0					mA	V_{CE} = 20 V, I_B = 0
					1.0			mA	V_{CE} = 30 V, I_B = 0
							1.0	mA	V_{CE} = 40 V, I_B = 0
I_{CEX}	Collector Cutoff Current		0.5					mA	V_{CE} = 45 V, V_{BE} = −1.5 V
					0.5			mA	V_{CE} = 65 V, V_{BE} = −1.5 V
							0.5	mA	V_{CE} = 85 V, V_{BE} = −1.5 V
			5.0					mA	V_{CE} = 40 V, V_{BE} = −1.5 V, T_C = 150°C
					5.0			mA	V_{CE} = 60 V, V_{BE} = −1.5 V, T_C = 150°C
							5.0	mA	V_{CE} = 80 V, V_{BE} = −1.5 V, T_C = 150°C
I_{CER}	Collector Cutoff Current		0.5					mA	V_{CE} = 35 V, R_{BE} = 100 Ω
					0.5			mA	V_{CE} = 55 V, R_{BE} = 100 Ω
							0.5	mA	V_{CE} = 75 V, R_{BE} = 100 Ω
I_{EBO}	Emitter Cutoff Current		1.0		1.0		1.0	mA	V_{EB} = 5.0 V, I_C = 0
ON CHARACTERISTICS									
h_{FE}	DC Current Gain (Note 1)	20	150	20	150	20	150		I_C = 5.0 A, V_{CE} = 4.0 V
		5.0		5.0		5.0			I_C = 15 A, V_{CE} = 4.0 V
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage (Note 1)		1.3		1.3		1.3	V	I_C = 5.0 A, I_B = 0.5 A
			3.5		3.5		3.5	V	I_C = 15 A, I_B = 5.0 A
$V_{BE(on)}$	Base-Emitter "On" Voltage (Note 1)		1.3		1.3		1.3	V	I_C = 5.0 A, V_{CE} = 4.0 V
			3.5		3.5		3.5	V	I_C = 15 A, V_{CE} = 4.0 V
DYNAMIC CHARACTERISTICS									
$\lvert h_{fe} \rvert$	Magnitude of Common Emitter Small Signal Current Gain	5.0		5.0		5.0			I_C = 1.0 A, V_{CE} = 4.0 V f = 1.0 MHz
h_{fe}	Small Signal Current Gain	25		25		25			I_C = 1.0 A, V_{CE} = 4.0 V f = 1.0 kHz

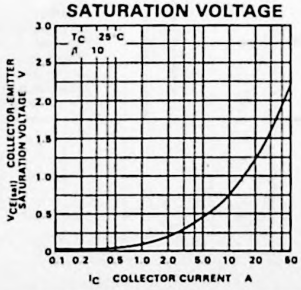
NOTE: 1. Pulse conditions: Length = 300 μs, Duty Cycle = 2%.

TYPICAL ELECTRICAL CHARACTERISTICS

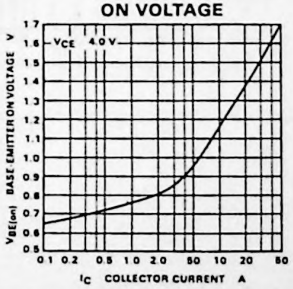
DC CURRENT GAIN



COLLECTOR-EMITTER SATURATION VOLTAGE



BASE-EMITTER ON VOLTAGE



POWER TRANSISTOR

PNP SILICON

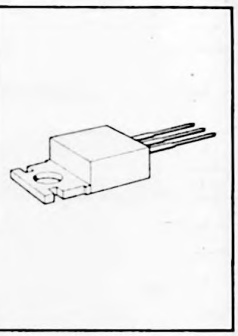
2N6489
2N6490
2N6491

GENERAL PURPOSE TRANSISTORS DESIGNED FOR MEDIUM POWER SWITCHING AND AMPLIFIER APPLICATIONS

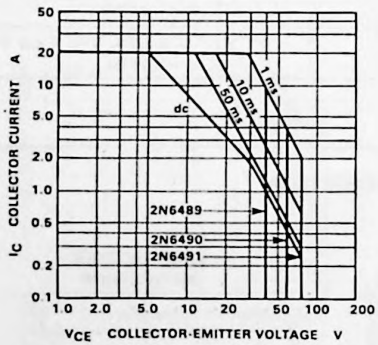
- 75 W DISSIPATION AT 25°C CASE
- 15 A MAXIMUM CONTINUOUS COLLECTOR CURRENT
- COMPLEMENT TO 2N6486, 2N6487, 2N6488

ABSOLUTE MAXIMUM RATINGS (Note 1)

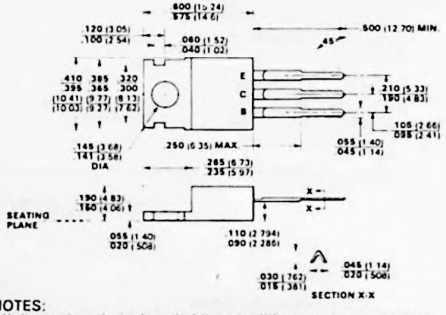
		2N6489	2N6490	2N6491
Maximum Voltages and Currents				
V_{CEO}	Collector to Emitter Voltage	−40 V	−60 V	−80 V
V_{CBO}	Collector to Base Voltage	−50 V	−70 V	−90 V
V_{EBO}	Emitter to Base Voltage	−5.0 V	−5.0 V	−5.0 V
I_C	Continuous Collector Current	15 A	15 A	15 A
I_B	Continuous Base Current	5.0 A	5.0 A	5.0 A
Maximum Power Dissipation				
P_D	Total Dissipation @ 25°C Case Temperature			75 W
	Derate Linearly from 25°C			0.6 W/°C
Maximum Temperatures				
T_J, T_{stg}	Storage and Operation Junction Temperatures			−65°C to +150°C
Thermal Characteristics				
$R_{\theta JC}$	Thermal Resistance, Junction to Case			1.67°C/W
T_P	Maximum Pin Temperature (Soldering, 10 s)			235°C



SAFE OPERATING AREA



JEDEC (TO-220) Outline**



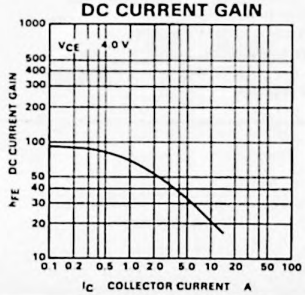
NOTES:
All dimensions in inches (bold) and millimeters (parentheses)
Package is silicone plastic with nickel-plated copper tab and pins
*Mechanically interchangeable with TO-66
Center pin is electrical contact with the mounting tab
Package weight is 2.1 grams
**Available in various pin configurations

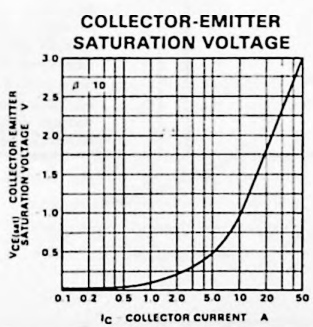
ELECTRICAL CHARACTERISTICS (25°C Case Temperature unless otherwise noted)

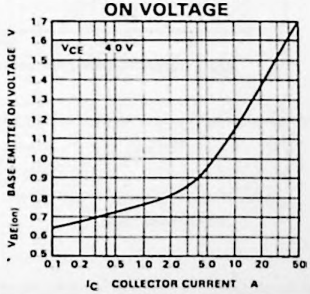
SYMBOL	CHARACTERISTIC	2N6489		2N6490		2N6491		UNIT	TEST CONDITIONS
		MIN	MAX	MIN	MAX	MIN	MAX		
OFF CHARACTERISTICS									
$V_{CEO(sus)}$	Collector-Emitter Sustaining Voltage (Note 1)	−40		−60		−80		V	I_C = 200 mA, I_B = 0
$V_{CER(sus)}$	Collector-Emitter Sustaining Voltage (Note 1)	−45		−65		−85		V	I_C = 200 mA, R_{BE} = 100 Ω
$V_{CEX(sus)}$	Collector-Emitter Sustaining Voltage (Note 1)	−50		−70		−90		V	I_C = 200 mA, $V_{BE(off)}$ = −1.5 V
I_{CEO}	Collector Cutoff Current		1.0					mA	V_{CE} = −20 V, I_B = 0
					1.0			mA	V_{CE} = −30 V, I_B = 0
							1.0	mA	V_{CE} = −40 V, I_B = 0
I_{CEX}	Collector Cutoff Current		0.5					mA	V_{CE} = −45 V, V_{BE} = 1.5 V
					0.5			mA	V_{CE} = −65 V, V_{BE} = 1.5 V
							0.5	mA	V_{CE} = −85 V, V_{BE} = 1.5 V
			5.0					mA	V_{CE} = −40V, V_{BE} = 1.5V, T_C = 150°C
					5.0			mA	V_{CE} = −60 V, V_{BE} = 1.5 V, T_C = 150°C
							5.0	mA	V_{CE} = −80 V, V_{BE} = 1.5 V, T_C = 150°C
I_{CER}	Collector Cutoff Current		0.5					mA	V_{CE} = −35 V, R_{BE} = 100 Ω
					0.5			mA	V_{CE} = −55 V, R_{BE} = 100 Ω
							0.5	mA	V_{CE} = −75 V, R_{BE} = 100 Ω
I_{EBO}	Emitter Cutoff Current		1.0		1.0		1.0	mA	V_{EB} = −5.0 V, I_C = 0
ON CHARACTERISTICS									
h_{FE}	DC Current Gain (Note 1)	20	150	20	150	20	150		I_C = 5.0 A, V_{CE} = −4.0 V
		5.0		5.0		5.0			I_C = 15 A, V_{CE} = −4.0 V
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage (Note 1)		−1.3		−1.3		−1.3	V	I_C = 5.0 A, I_B = 0.5 A
			−3.5		−3.5		−3.5	V	I_C = 15 A, I_B = 5.0 A
$V_{BE(on)}$	Base-Emitter "On" Voltage (Note 1)		−1.3		−1.3		−1.3	V	I_C = 5.0 A, V_{CE} = −4.0 V
			−3.5		−3.5		−3.5	V	I_C = 15 A, V_{CE} = −4.0 V
DYNAMIC CHARACTERISTICS									
$\lvert h_{fe} \rvert$	Magnitude of Common Emitter Small Signal Current Gain	5.0		5.0		5.0			I_C = 1.0 A, V_{CE} = −4.0 V, f = 1.0 MHz
h_{fe}	Small Signal Current Gain	25		25		25			I_C = 1.0 A, V_{CE} = −4.0 V, f = 1.0 kHz

NOTE: 1. Pulse conditions: Length = 300 μs, Duty Cycle = 2%.

TYPICAL ELECTRICAL CHARACTERISTICS







POWER TRANSISTOR

NPN SILICON

2N6569

GENERAL PURPOSE POWER TRANSISTOR DESIGNED FOR LOW VOLTAGE AMPLIFIER AND POWER SWITCHING

- 100 W DISSIPATION AT 25°C CASE
- 12 A MAXIMUM CONTINUOUS COLLECTOR CURRENT
- ALL PURPOSE REPLACEMENT FOR INDUSTRY STANDARD 2N3055
- COST EFFECTIVE
- METAL CAN RELIABILITY IN TO-3 PACKAGE

ABSOLUTE MAXIMUM RATINGS

Maximum Voltages and Currents

V_{CE}	Collector to Emitter Voltage	40 V
V_{CB}	Collector to Base Voltage	45 V
V_{EB}	Emitter to Base Voltage	5 V
I_C	Continuous Collector Current	12 A
I_C	Peak Collector Current	24 A
I_B	Continuous Base Current	5 A

Maximum Power Dissipation

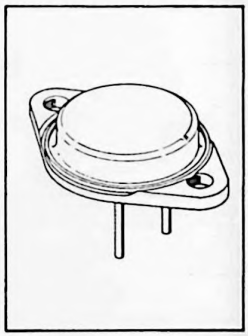
P_D	Total Dissipation @ 25°C Case Temperature	100 W
	Derate Linearly from 25°C	0.8 W/°C

Maximum Temperatures

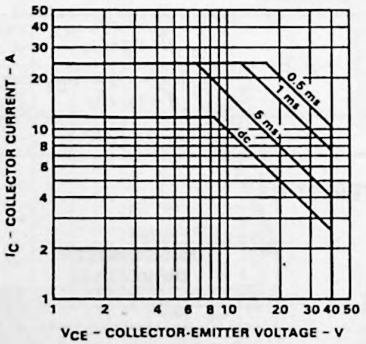
T_J, T_{stg}	Storage and Operating Junction Temperatures	−65°C to +200°C

Thermal Characteristics

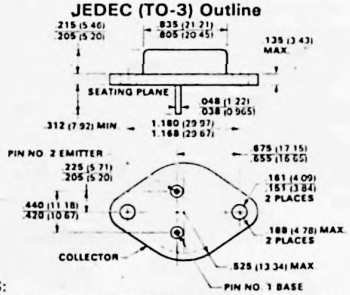
$R_{\theta JC}$	Thermal Resistance, Junction to Case	1.75°C/W
T_P	Maximum Pin Temperature (Soldering, 5 s)	265°C



SAFE OPERATING AREA



JEDEC (TO-3) Outline



NOTES:
All dimensions in inches (bold) and millimeters (parentheses)
Pins are gold-plated or solder-dipped alloy 52
Pins 1 and 2 electrically isolated from case
Case is third electrical connection
Aluminum package with copper slug, pins are soldered in
Package weight is 7.4 grams
Aluminum cap

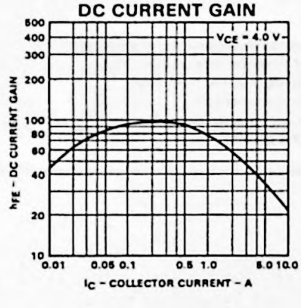
ELECTRICAL CHARACTERISTICS (25°C Case Temperature unless otherwise noted)

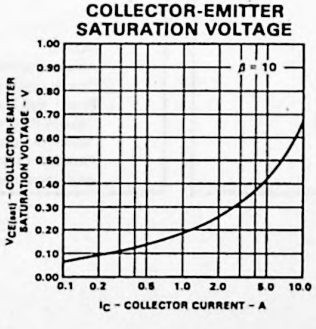
SYMBOL	CHARACTERISTIC	MIN	MAX	UNITS	TEST CONDITIONS
OFF CHARACTERISTICS					
$V_{CEO(sus)}$	Collector-Emitter Sustaining Voltage (Note 1)	40		V	I_C = 200 mA, I_B = 0
I_{CEV}	Collector Cutoff Current		1.0 10	mA	V_{CE} = 45 V, V_{BE} = −1.5 V V_{CE} = 45 V, V_{BE} = −1.5 V, T_C = 100°C
I_{EBO}	Emitter Cutoff Current		5.0	mA	V_{EB} = 5.0 V, I_C = 0
ON CHARACTERISTICS					
h_{FE}	DC Current Gain (Note 1)	15 5.0	200 100		I_C = 4.0 A, V_{CE} = 3.0 V I_C = 12 A, V_{CE} = 4.0 V
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage (Note 1)		1.5 4.0	V	I_C = 4.0 A, I_B = 0.4 A I_C = 12 A, I_B = 2.4 A
$V_{BE(sat)}$	Base-Emitter Saturation Voltage (Note 1)		2.0	V	I_C = 4.0 A, I_B = 0.4 A
SECOND BREAKDOWN					
$I_{s/b}$	Second Breakdown Collector Current with Base Forward Biased	2.5		A	t = 1.0 s (non-repetitive) V_{CE} = 40 V
DYNAMIC CHARACTERISTICS					
f_T	Current-Gain-Bandwidth Product	1.5	15	MHz	I_C = 1.0 A, V_{CE} = 4.0 V, f = 0.5 MHz
C_{ob}	Output Capacitance	75	750	pF	V_{CB} = 10 V, I_E = 0, f = 1.0 MHz
SWITCHING CHARACTERISTICS					
RESISTIVE LOAD					
t_d	Delay Time		0.4	μs	V_{CC} = 30 V, I_C = 2.0 A, I_{B1} = 0.2 A
t_r	Rise Time		1.5	μs	t_p = 25 μs, Duty Cycle ≤ 1.0%
t_s	Storage Time		5.0	μs	V_{CC} = 30 V, I_C = 2.0 A, I_{B1} = I_{B2} = 0.2 A
t_f	Fall Time		1.5	μs	t_p = 25 μs, Duty Cycle ≤ 1.0%

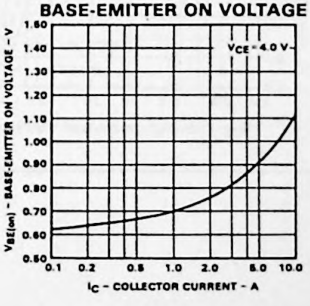
NOTE: 1. Pulse conditions: Length = 300 μs, Duty Cycle = 2%.

6

TYPICAL ELECTRICAL CHARACTERISTICS







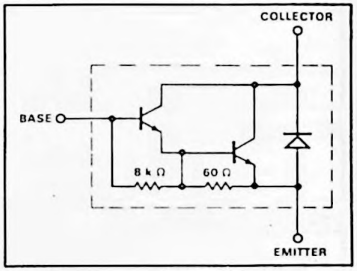
POWER DARLINGTON

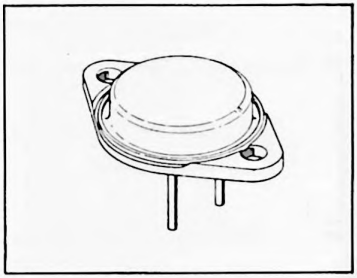
NPN SILICON

2N6576
2N6577

GENERAL PURPOSE DARLINGTON SUITABLE FOR POWER AMPLIFIER AND SERIES PASS REGULATOR APPLICATIONS

- 120 W DISSIPATION AT 25°C CASE
- 15 A MAXIMUM CONTINUOUS COLLECTOR CURRENT
- COST EFFECTIVE REPLACEMENT FOR 2N3055 AND DRIVER
- HIGH GAIN DARLINGTON PERFORMANCE
- REVERSE POLARITY DIODE PROTECTION

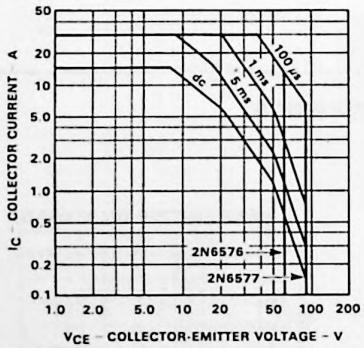




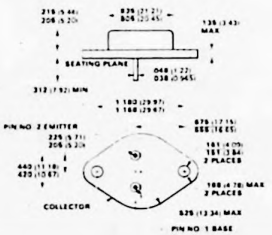
ABSOLUTE MAXIMUM RATINGS

		2N6576	2N6577
Maximum Voltages and Currents			
V_{CE}	Collector to Emitter Voltage	60 V	90 V
V_{CB}	Collector to Base Voltage	60 V	90 V
V_{EB}	Emitter to Base Voltage	7 V	7 V
I_C	Continuous Collector Current	15 A	15 A
I_C	Peak Collector Current	30 A	30 A
I_B	Continuous Base Current	.25 A	.25 A
Maximum Power Dissipation			
P_D	Total Dissipation @ 25°C Case Temperature		120 W
	Derate Linearly from 25°C		.685 W/°C
Maximum Temperatures			
T_J, T_{stg}	Storage and Operation Junction Temperatures		−65°C to +200°C
Thermal Characteristics			
$R_{\theta JC}$	Thermal Resistance, Junction to Case		1.46°C/W
T_P	Maximum Pin Temperature (Soldering, 5s)		265°C

SAFE OPERATING AREA



JEDEC (TO-3) Outline



NOTES:
All dimensions in inches (bold) and millimeters (parentheses)
Pins are gold-plated or solder-dipped alloy 52
Pins 1 and 2 electrically isolated from case
Case is third electrical connection
Aluminum package with copper slug, pins are soldered in
Package weight is 7.4 grams
Aluminum cap

ELECTRICAL CHARACTERISTICS (25°C Case Temperature unless otherwise noted)

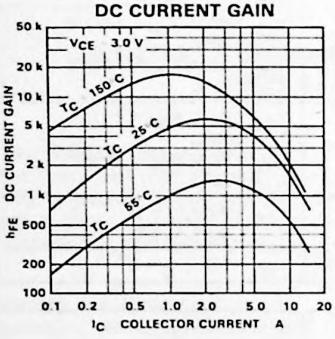
SYMBOL	CHARACTERISTIC	2N6576		2N6577		UNIT	TEST CONDITIONS
		MIN	MAX	MIN	MAX		
OFF CHARACTERISTICS							
$V_{CEO(sus)}$	Collector-Emitter Sustaining Voltage (Note 1)	60		90		V	I_C = 200 mA, I_B = 0
I_{CEO}	Collector Cutoff Current		1.0		1.0	mA	V_{CE} = 60 V, I_B = 0 V_{CE} = 90 V, I_B = 0
I_{CEV}	Collector Cutoff Current		5.0		5.0	mA	V_{CE} = 60 V, V_{BE} = −1.5 V, T_C = 175°C V_{CE} = 90 V, V_{BE} = −1.5 V, T_C = 175°C
I_{CER}	Collector Cutoff Current		5.0		5.0	mA	V_{CE} = 60 V, R_{BE} = 10 kΩ, T_C = 150°C V_{CE} = 90 V, R_{BE} = 10 kΩ, T_C = 150°C
I_{CBO}	Collector Cutoff Current		0.5		0.5	mA	V_{CB} = 60 V, I_E = 0 V_{CB} = 90 V, I_E = 0
I_{EBO}	Emitter Cutoff Current		7.5		7.5	mA	V_{EB} = 7.0 V, I_C = 0
ON CHARACTERISTICS							
h_{FE}	DC Current Gain (Note 1)	100 500 2000 200	5000 20,000	100 500 2000 200	5000 20,000		I_C = 15 A, V_{CE} = 4.0 V I_C = 10 A, V_{CE} = 3.0 V I_C = 4.0 A, V_{CE} = 3.0 V I_C = 0.4 A, V_{CE} = 3.0 V
$V_{CE(sat)}$	Collector-Emitter Voltage (Note 1)		4.0 2.8		4.0 2.8	V	I_C = 15 A, I_B = 0.15 A I_C = 10 A, I_B = 0.1 A
$V_{BE(sat)}$	Base-Emitter Saturation Voltage (Note 1)		4.5 3.5		4.5 3.5	V	I_C = 15 A, I_B = 0.15 A I_C = 10 A, I_B = 0.1 A
V_{EC}	Collector-Emitter Diode Voltage Drop		3.5		3.5	V	I_{EC} = 15 A
DYNAMIC CHARACTERISTICS							
$\|h_{fe}\|$	Magnitude of Common Emitter Small Signal Current Gain	10	200	10	200		I_C = 3.0 A, V_{CE} = 3.0 V, f = 1.0 MHz
SWITCHING CHARACTERISTICS							
RESISTIVE LOAD							
t_d	Delay Time		0.15		0.15	μs	V_{CC} = 30 V, I_C = 10 A, I_{B1} = 0.1 A
t_r	Rise Time		1.0		1.0	μs	t_p = 300 μs, Duty Cycle ≤ 2.0%
t_s	Storage Time		2.0		2.0	μs	V_{CC} = 30 V, I_C = 10 A, I_{B1} = I_{B2} = 0.1 A, t_p = 300 μs, Duty Cycle ≤ 2.0%
t_f	Fall Time		7.0		7.0	μs	

NOTE 1. Pulse conditions: Length = 300 μs, Duty Cycle = 2%.

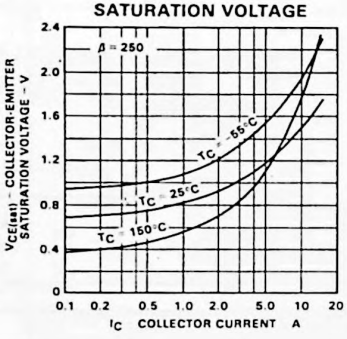
6

TYPICAL ELECTRICAL CHARACTERISTICS

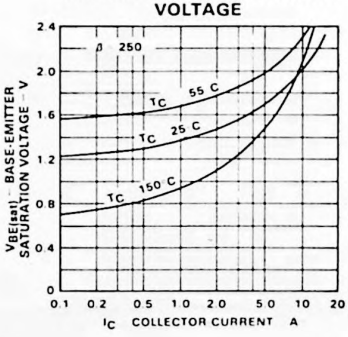
DC CURRENT GAIN



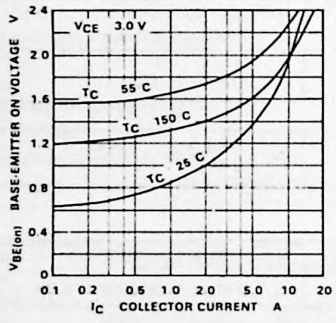
COLLECTOR-EMITTER SATURATION VOLTAGE



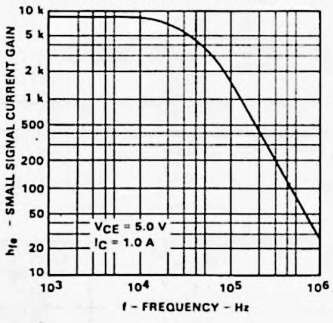
BASE-EMITTER SATURATION VOLTAGE



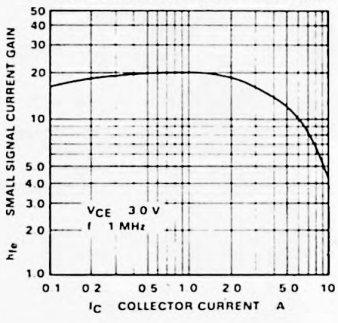
BASE-EMITTER-ON VOLTAGE



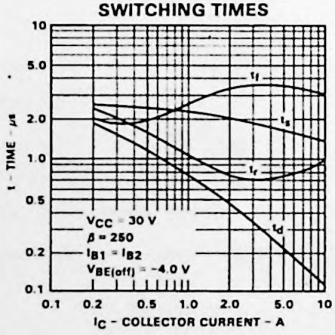
SMALL SIGNAL CURRENT GAIN



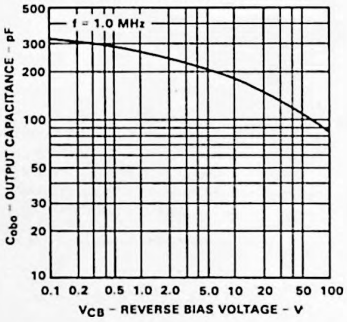
SMALL SIGNAL CURRENT GAIN



SWITCHING TIMES



OUTPUT CAPACITANCE



POWER TRANSISTOR

NPN SILICON

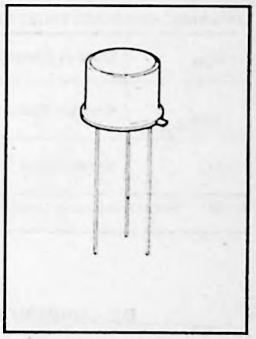
BC323

GENERAL PURPOSE POWER DEVICE FOR EUROPEAN MARKET

- 7.0 W DISSIPATION AT 25°C CASE
- 5.0 A MAXIMUM CONTINUOUS COLLECTOR CURRENT
- 0.15 $V_{CE(sat)}$ MAXIMUM @ 500 mA

ABSOLUTE MAXIMUM RATINGS (Note 1)

		BC323
Maximum Voltages and Currents		
V_{CEO}	Collector to Emitter Voltage	60 V
V_{CBO}	Collector to Base Voltage	100 V
V_{EBO}	Emitter to Base Voltage	5.0 V
I_C	Continuous Collector Current	5.0 A
Maximum Power Dissipation		
P_D	Total Dissipation @ 25°C Case Temperature	7.0 W
	Derate Linearly from 25°C	40 mW/°C
Maximum Temperatures		
T_J, T_{stg}	Storage and Operation Junction Temperatures	−65°C to +200°C
Thermal Characteristics		
$R_{\theta JC}$	Thermal Resistance, Junction to Case	25°C/W



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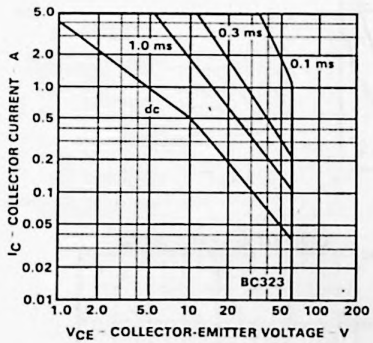
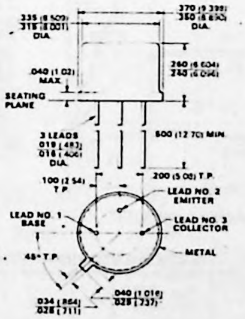
SAFE OPERATING AREA



JEDEC (TO-39) Outline



NOTES:
All dimensions in inches (bold) and millimeters (parentheses)
Leads are gold-plated kovar
Lead No. 3 connected to case
Package weight is 1.23 grams

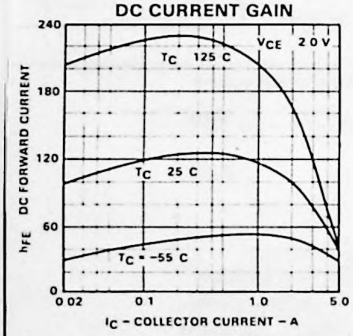
ELECTRICAL CHARACTERISTICS (25°C Case Temperature unless otherwise noted)

SYMBOL	CHARACTERISTIC	BC323 MIN	BC323 MAX	UNIT	TEST CONDITIONS
OFF CHARACTERISTICS					
$V_{CEO(sus)}$	Collector-Emitter Sustaining Voltage (Note 1)	60		V	I_C = 50 mA, I_B = 0
V_{CES}	Collector-Emitter Breakdown Voltage	100		V	I_C = 1.0 mA, V_{BE} = 0
V_{EBO}	Emitter-Base Breakdown Voltage	5.0		V	I_E = 1.0 mA, I_C = 0
I_{CBO}	Collector Cutoff Current		0.1	mA	V_{CB} = 100 V, I_E = 0
			0.01	mA	V_{CB} = 40 V, I_E = 0
		0.35 TYP		μA	V_{CB} = 40 V, I_E = 0, T_C = 75°C
I_{EBO}	Emitter Cutoff Current		0.01	mA	V_{EB} = 4.0 V, I_C = 0
ON CHARACTERISTICS					
h_{FE}	DC Current Gain (Note 1)	40	225		I_C = 50 mA, V_{CE} = 1.0 V
		50	250		I_C = 500 mA, V_{CE} = 1.0 V
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage (Note 1)		0.15	V	I_C = 500 mA, I_B = 50 mA
$V_{BE(sat)}$	Base-Emitter Saturation Voltage (Note 1)		0.9	V	I_C = 500 mA, I_B = 50 mA
DYNAMIC CHARACTERISTICS					
C_{ob}	Output Capacitance		80	pF	V_{CB} = 10 V, I_E = 0, f = 1.0 MHz
C_{eb}	Emitter-Transition Capacitance		500	pF	V_{EB} = 0.5 V, I_C = 0, f = 1.0 MHz
h_{fe}	Small Signal Current Gain	5.0 TYP			I_C = 500 mA, V_{CE} = 5.0 V, f = 20 MHz

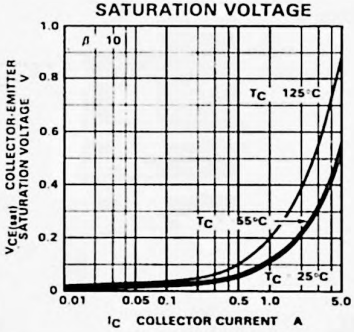
NOTE: 1. Pulse conditions: Length = 300 μs, Duty Cycle = 2%.

TYPICAL ELECTRICAL CHARACTERISTICS

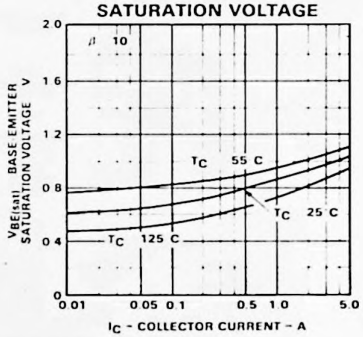
DC CURRENT GAIN



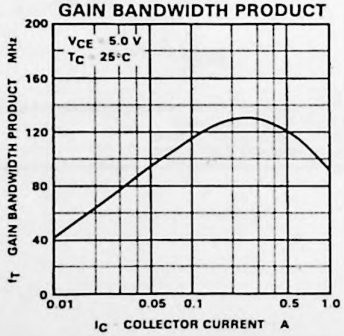
COLLECTOR-EMITTER SATURATION VOLTAGE



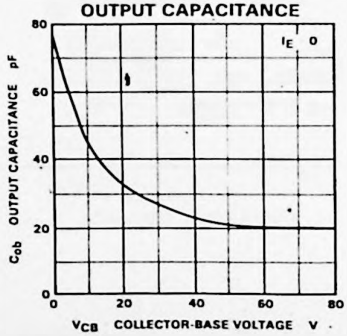
BASE-EMITTER SATURATION VOLTAGE



GAIN BANDWIDTH PRODUCT



OUTPUT CAPACITANCE



POWER TRANSISTOR

NPN SILICON

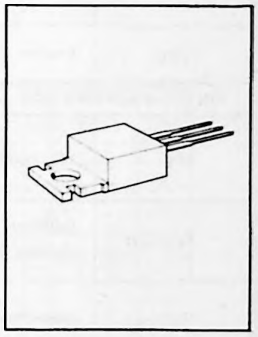
BD220
BD221
BD222

GENERAL PURPOSE DEVICE FOR EUROPEAN MARKET

- 36 W DISSIPATION AT 25°C CASE
- 4.0 A MAXIMUM CONTINUOUS COLLECTOR CURRENT
- COMPLEMENTS BD223, BD224, BD225

ABSOLUTE MAXIMUM RATINGS (Note 1)

		BD220	BD221	BD222
Maximum Voltages and Currents				
V_{CEO}	Collector to Emitter Voltage	70 V	40 V	60 V
V_{CBO}	Collector to Base Voltage	80 V	60 V	80 V
V_{EBO}	Emitter to Base Voltage	7.0 V	7.0 V	7.0 V
I_C	Continuous Collector Current	4.0 A	4.0 A	4.0 A
I_B	Continuous Base Current	2.0 A	2.0 A	2.0 A
Maximum Power Dissipation				
P_D	Total Dissipation @ 25°C Case Temperature			36 W
	Derate Linearly from 25°C			288 mW/°C
Maximum Temperatures				
T_J, T_{stg}	Storage and Operation Junction Temperatures			−65°C to +150°C
Thermal Characteristics				
$R_{\theta JC}$	Thermal Resistance, Junction to Case			3.47°C/W



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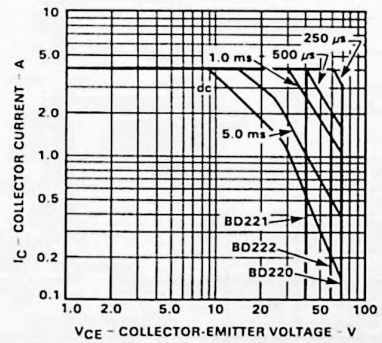
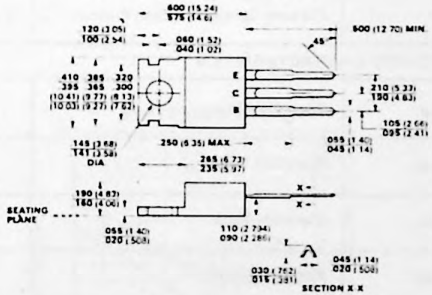
SAFE OPERATING AREA



JEDEC (TO-220) Outline**



NOTES:
All dimensions in inches (bold) and millimeters (parentheses)
Package is silicone plastic with nickel-plated copper tab and pins
*Mechanically interchangeable with TO-66
Center pin is electrical contact with the mounting tab
Package weight is 2.1 grams
**Available in various pin configurations

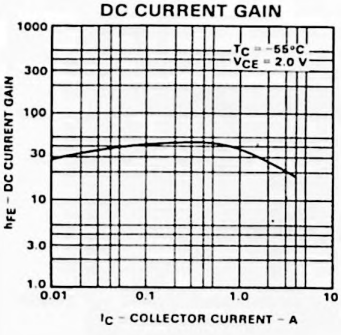
ELECTRICAL CHARACTERISTICS (25°C Case Temperature unless otherwise noted)

SYMBOL	CHARACTERISTIC	BD220		BD221		BD222		UNIT	TEST CONDITIONS
		MIN	MAX	MIN	MAX	MIN	MAX		
OFF CHARACTERISTICS									
$V_{CEO(sus)}$	Collector-Emitter Sustaining Voltage (Note 1)	70		40		60		V	I_C = 100 mA, I_B = 0
I_{CEV}	Collector Cutoff Current		0.5				0.5	mA	V_{CE} = 65 V, V_{BE} = -1.5 V
					2.0			mA	V_{CE} = 35 V, V_{BE} = -1.5 V
			10				10	mA	V_{CE} = 80 V, V_{BE} = -1.5 V
					10			mA	V_{CE} = 60 V, V_{BE} = -1.5 V
			3.0				3.0	mA	V_{CE} = 65 V, V_{BE} = -1.5 V, T_C = 150°C
					5.0			mA	V_{CE} = 35 V, V_{BE} = -1.5 V, T_C = 150°C
I_{CER}	Collector Cutoff Current		0.5				0.5	mA	V_{CE} = 50 V, R_{BE} = 100 Ω
			10					mA	V_{CE} = 75 V, R_{BE} = 100 Ω
					10			mA	V_{CE} = 50 V, R_{BE} = 100 Ω
							10	mA	V_{CE} = 70 V, R_{BE} = 100 Ω
			2.0				2.0	mA	V_{CE} = 50 V, R_{BE} = 100 Ω, T_C = 150°C
I_{EBO}	Emitter Cutoff Current		1.0					mA	V_{EB} = 7.0 V, I_C = 0
					1.0		1.0	mA	V_{EB} = 5.0 V, I_C = 0
ON CHARACTERISTICS									
h_{FE}	DC Current Gain (Note 1)	30	120						I_C = 0.5 A, V_{CE} = 4.0 V
				30	120				I_C = 1.0 A, V_{CE} = 4.0 V
						20	80		I_C = 1.5 A, V_{CE} = 4.0 V
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage (Note 1)		1.0					V	I_C = 0.5 A, I_B = 0.05 A
					1.0			V	I_C = 1.0 A, I_B = 0.1 A
							1.0	V	I_C = 1.5 A, I_B = 0.15 A
$V_{BE(on)}$	Base-Emitter "On" Voltage (Note 1)		1.1					V	I_C = 0.5 A, V_{CE} = 4.0 V
					1.3			V	I_C = 1.0 A, V_{CE} = 4.0 V
							1.5	V	I_C = 1.5 A, V_{CE} = 4.0 V
DYNAMIC CHARACTERISTICS									
f_T	Current-Gain-Bandwidth Product	0.8		0.8		0.8		MHz	I_C = 0.2 A, V_{CE} = 4.0 V, f = 0.1 MHz
SWITCHING CHARACTERISTICS									
t_{on}	Turn On Time		0.5					μs	I_C = 0.5 A, V_{CC} = 30 V, I_{B1} = 50 mA
t_{off}	Turn Off Time		15					μs	I_C = 0.5 A, V_{CC} = 30 V, I_{B1} = I_{B2} = 50 mA
t_{on}	Turn On Time				0.5			μs	I_C = 1.0 A, V_{CC} = 30 V, I_{B1} = 100 mA
t_{off}	Turn Off Time				15			μs	I_C = 1.0 A, V_{CC} = 30 V, I_{B1} = I_{B2} = 100 mA
t_{on}	Turn On Time						0.5	μs	I_C = 1.5 A, V_{CC} = 30 V, I_{B1} = 150 mA
t_{off}	Turn Off Time						15	μs	I_C = 1.5 A, V_{CC} = 30 V, I_{B1} = I_{B2} = 150 mA

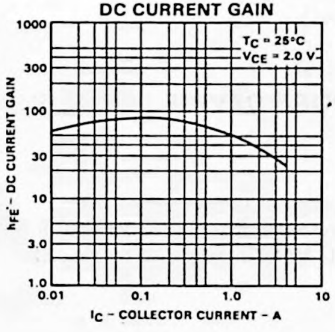
NOTE: 1. Pulse conditions: Length = 300 μs, Duty Cycle = 2%.

TYPICAL ELECTRICAL CHARACTERISTICS

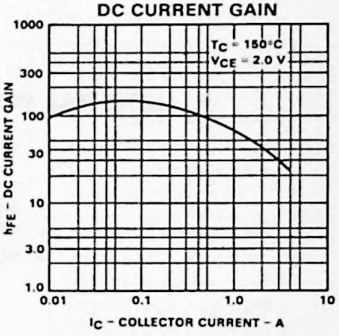
DC CURRENT GAIN



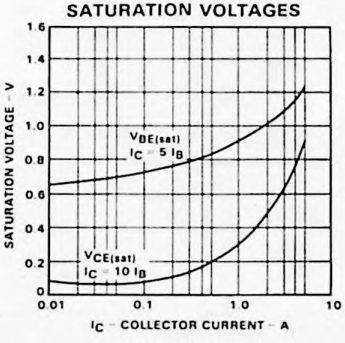
DC CURRENT GAIN



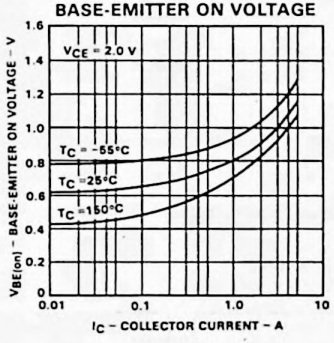
DC CURRENT GAIN



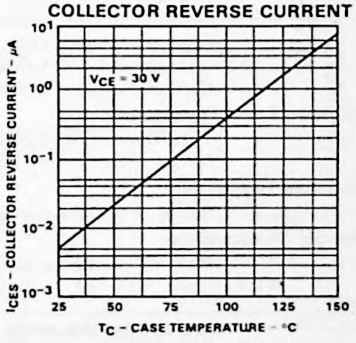
SATURATION VOLTAGES



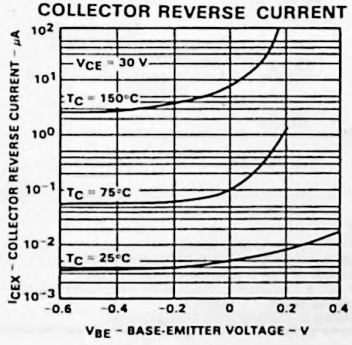
BASE-EMITTER ON VOLTAGE



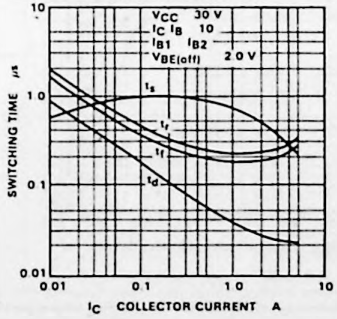
COLLECTOR REVERSE CURRENT



COLLECTOR REVERSE CURRENT



SWITCHING TIMES



6

POWER TRANSISTOR

PNP SILICON

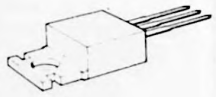
BD223
BD224
BD225

GENERAL PURPOSE DEVICE FOR EUROPEAN MARKET

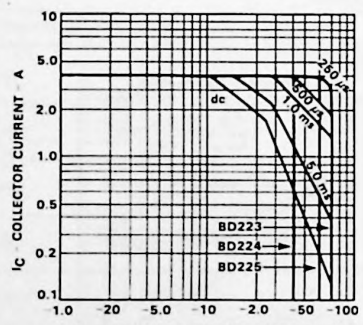
- 36 W DISSIPATION AT 25°C CASE
- 4.0 A MAXIMUM CONTINUOUS COLLECTOR CURRENT
- COMPLEMENTS BD220, BD221, BD222

ABSOLUTE MAXIMUM RATINGS (Note 1)

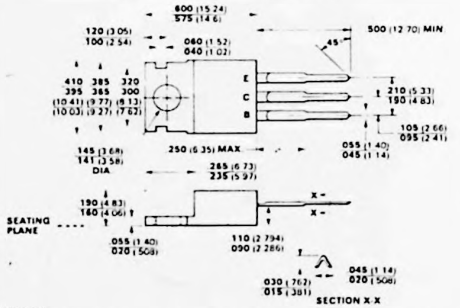
		BD223	BD224	BD225
Maximum Voltages and Currents				
V_{CEO}	Collector to Emitter Voltage	−70 V	−40 V	−60 V
V_{CBO}	Collector to Base Voltage	−80 V	−60 V	−80 V
V_{EBO}	Emitter to Base Voltage	−7.0 V	−7.0 V	−7.0 V
I_C	Continuous Collector Current	4.0 A	4.0 A	4.0 A
I_B	Continuous Base Current	2.0 A	2.0 A	2.0 A
Maximum Power Dissipation				
P_D	Total Dissipation @ 25°C Case Temperature			36 W
	Derate Linearly from 25°C			288 mW/°C
Maximum Temperatures				
T_J, T_{stg}	Storage and Operation Junction Temperatures			−65°C to +150°C
Thermal Characteristics				
$R_{\theta JC}$	Thermal Resistance, Junction to Case			3.47°C/W



SAFE OPERATING AREA



JEDEC (TO-220) Outline**



NOTES:
All dimensions in inches (bold) and millimeters (parentheses)
Package is silicone plastic with nickel-plated copper tab and pins
*Mechanically interchangeable with TO-66
Center pin is electrical contact with the mounting tab
Package weight is 2.1 grams
**Available in various pin configurations

ELECTRICAL CHARACTERISTICS (25°C Case Temperature unless otherwise noted)

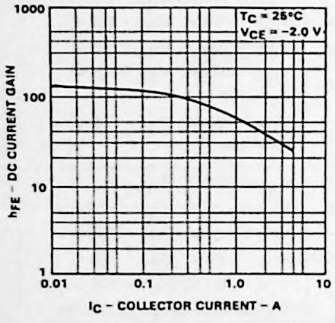
SYMBOL	CHARACTERISTIC	BD223		BD224		BD225		UNIT	TEST CONDITIONS
		MIN	MAX	MIN	MAX	MIN	MAX		
OFF CHARACTERISTICS									
$V_{CEO(sus)}$	Collector-Emitter Sustaining Voltage (Note 1)	−70		−40		−60		V	I_C = 100 mA, I_B = 0
I_{CEV}	Collector Cutoff Current		0.5				0.5	mA	V_{CE} = −65 V, V_{BE} = 1.5 V
					2.0			mA	V_{CE} = −35 V, V_{BE} = 1.5 V
			10				10	mA	V_{CE} = −80 V, V_{BE} = 1.5 V
					10			mA	V_{CE} = −60 V, V_{BE} = 1.5 V
			3.0				3.0	mA	V_{CE} = −65 V, V_{BE} = 1.5 V, T_C = 150°C
					5.0			mA	V_{CE} = −35 V, V_{BE} = 1.5 V, T_C = 150°C
I_{CER}	Collector Cutoff Current		0.5				0.5	mA	V_{CE} = −50 V, R_{BE} = 100 Ω
			10					mA	V_{CE} = −75 V, R_{BE} = 100 Ω
					10			mA	V_{CE} = −50 V, R_{BE} = 100 Ω
							10	mA	V_{CE} = −70 V, R_{BE} = 100 Ω
			2.0				2.0	mA	V_{CE} = −50 V, R_{BE} = 100 Ω, T_C = 150°C
I_{EBO}	Emitter Cutoff Current		1.0					mA	V_{EB} = −7.0 V, I_C = 0
I_{EBO}	Emitter Cutoff Current				1.0		1.0	mA	V_{EB} = −5.0 V, I_C = 0
ON CHARACTERISTICS									
h_{FE}	DC Current Gain (Note 1)	30	120	30	120				I_C = 0.5 A, V_{CE} = −4.0 V
						20	80		I_C = 1.0 A, V_{CE} = −4.0 V
									I_C = 1.5 A, V_{CE} = −4.0 V
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage (Note 1)		−1.0					V	I_C = 0.5 A, I_B = 50 mA
					−1.0			V	I_C = 1.0 A, I_B = 100 mA
							−1.0	V	I_C = 1.5 A, I_B = 150 mA
$V_{BE(on)}$	Base-Emitter "On" Voltage (Note 1)		−1.1					V	I_C = 0.5 A, V_{CE} = −4.0 V
					−1.3			V	I_C = 1.0 A, V_{CE} = −4.0 V
							−1.5	V	I_C = 1.5 A, V_{CE} = −4.0 V
DYNAMIC CHARACTERISTICS									
f_T	Current-Gain-Bandwidth Product	0.8		0.8		0.8		MHz	I_C = 0.2 A, V_{CE} = −4.0 V, f = 0.1 MHz
SWITCHING CHARACTERISTICS									
t_{on}	Turn On Time		5.0					μs	I_C = 0.5 A, V_{CC} = −30 V, I_{B1} = 50 mA
t_{off}	Turn Off Time		15					μs	I_C = 0.5 A, V_{CC} = −30 V, I_{B1} = I_{B2} = 50 mA
t_{on}	Turn On Time				5.0			μs	I_C = 1.0 A, V_{CC} = −30 V, I_{B1} = 100 mA
t_{off}	Turn Off Time				15			μs	I_C = 1.0 A, V_{CC} = −30 V, I_{B1} = I_{B2} = 100 mA
t_{on}	Turn On Time						5.0	μs	I_C = 1.5 A, V_{CC} = −30 V, I_{B1} = 150 mA
t_{off}	Turn Off Time						15	μs	I_C = 1.5 A, V_{CC} = −30 V, I_{B1} = I_{B2} = 150 mA

NOTE: 1. Pulse conditions: Length = 300 μs, Duty Cycle = 2%.

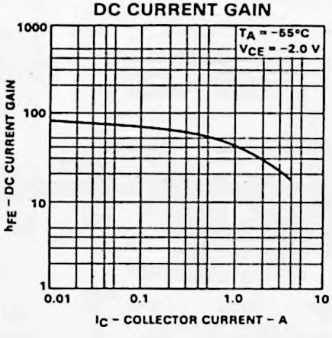
6

TYPICAL ELECTRICAL CHARACTERISTICS

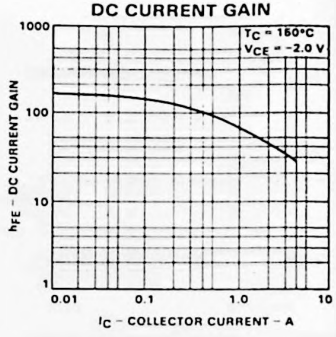
DC CURRENT GAIN



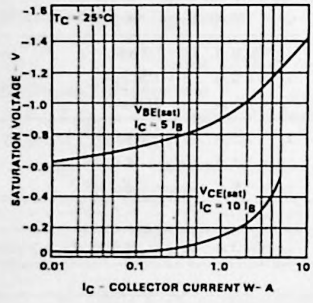
DC CURRENT GAIN



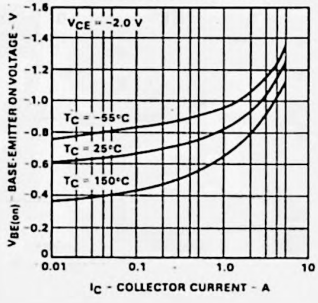
DC CURRENT GAIN



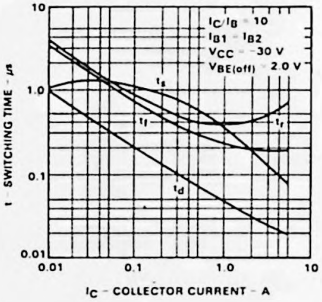
SATURATION VOLTAGES



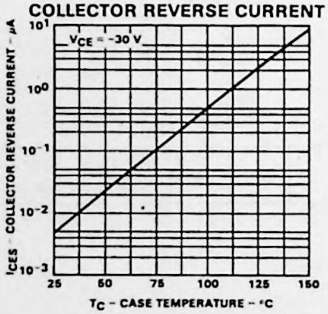
BASE-EMITTER ON VOLTAGE



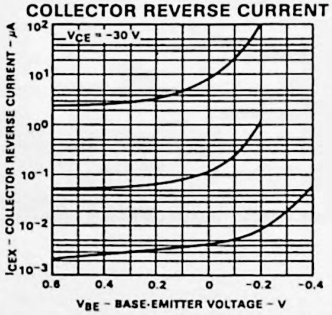
SWITCHING TIMES



COLLECTOR REVERSE CURRENT



COLLECTOR REVERSE CURRENT



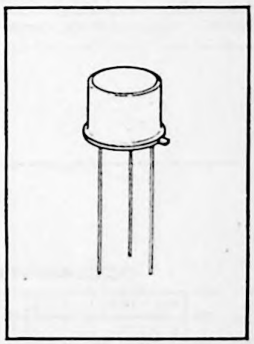
POWER TRANSISTOR

NPN SILICON

BF257
BF258
BF259

DESIGNED AS HIGH VOLTAGE VIDEO DRIVERS

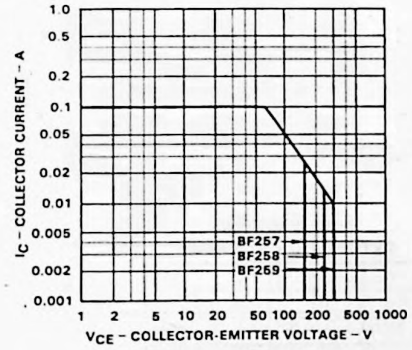
- 7.0 W DISSIPATION AT 25°C CASE
- 100 mA MAXIMUM CONTINUOUS COLLECTOR CURRENT
- 300 V V_{CEO} MINIMUM (BF259)



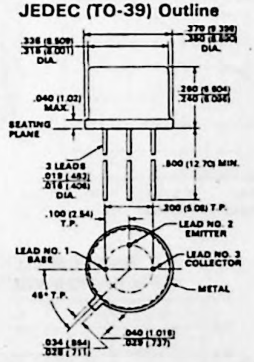
ABSOLUTE MAXIMUM RATINGS (Note 1)

		BF257	BF258	BF259
Maximum Voltages and Currents				
V_{CEO}	Collector to Emitter Voltage	160 V	250 V	300 V
V_{CBO}	Collector to Base Voltage	160 V	250 V	300 V
V_{EBO}	Emitter to Base Voltage	5.0 V	5.0 V	5.0 V
I_C	Continuous Collector Current	100 mA	100 mA	100 mA
Maximum Power Dissipation				
P_D	Total Dissipation @ 25°C Case Temperature			7.0 W
	Derate Linearly from 25°C			40 mW/°C
Maximum Temperatures				
T_J, T_{stg}	Storage and Operation Junction Temperatures			−65°C to +200°C
Thermal Characteristics				
$R_{\theta JC}$	Thermal Resistance, Junction to Case			25°C/W

SAFE OPERATING AREA



JEDEC (TO-39) Outline



NOTES:
All dimensions in inches (bold) and millimeters (parentheses)
Leads are gold-plated kovar
Lead No. 3 connected to case
Package weight is 0.76 gram

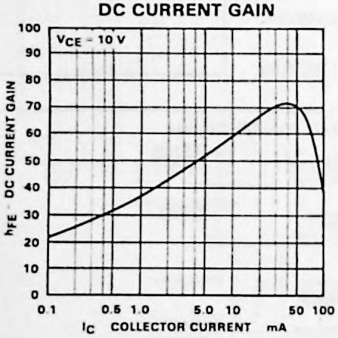
6

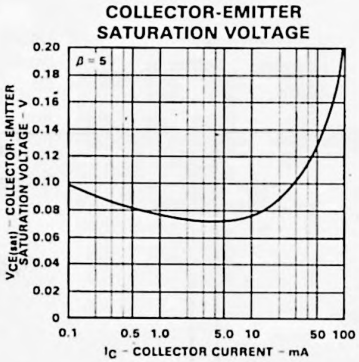
ELECTRICAL CHARACTERISTICS (25°C Case Temperature unless otherwise noted)

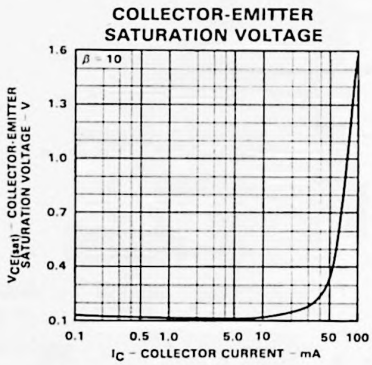
SYMBOL	CHARACTERISTIC	BF257		BF258		BF259		UNIT	TEST CONDITIONS
		MIN	MAX	MIN	MAX	MIN	MAX		
OFF CHARACTERISTICS									
$V_{CEO(sus)}$	Collector-Emitter Sustaining Voltage (Note 1)	160		250		300		V	I_C = 10 mA, I_B = 0
V_{CBO}	Collector-Base Breakdown Voltage	160		250		300		V	I_C = 0.1 mA, I_E = 0
V_{EBO}	Emitter-Base Breakdown Voltage	5.0		5.0		5.0		V	I_E = 0.1 mA, I_C = 0
I_{CBO}	Collector Cutoff Current		50		50		50	nA nA nA	V_{CB} = 100 V, I_E = 0 V_{CB} = 200 V, I_E = 0 V_{CB} = 250 V, I_E = 0
ON CHARACTERISTICS									
h_{FE}	DC Current Gain (Note 1)	25		25		25			I_C = 30 mA, V_{CE} = 10 V
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage (Note 1)		1.0		1.0		1.0	V	I_C = 30 mA, I_B = 6.0 mA
DYNAMIC CHARACTERISTICS									
f_T	Current-Gain-Bandwidth Product	75 TYP		75 TYP		75 TYP		MHz	I_C = 15 mA, V_{CE} = 10 V, f = 10 MHz
C_{cb}	Collector-Base Capacitance	3.5 TYP		3.0 TYP		2.5 TYP			V_{CB} = 30 V, I_E = 0, f = 1.0 MHz

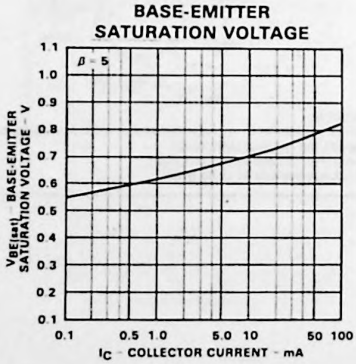
NOTE: 1. Pulse conditions: Length = 300 μs, Duty Cycle = 2%.

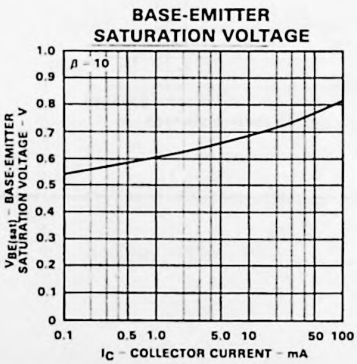
TYPICAL ELECTRICAL CHARACTERISTICS











POWER TRANSISTOR

NPN SILICON

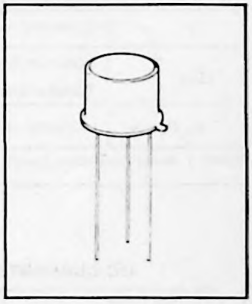
BF336
BF337
BF338

DESIGNED AS HIGH VOLTAGE VIDEO DRIVERS

- 1.0 W DISSIPATION AT 25°C CASE
- 100 mA MAXIMUM CONTINUOUS COLLECTOR CURRENT
- 225 V V_{CEO} MINIMUM BF338

ABSOLUTE MAXIMUM RATINGS (Note 1)

		BF336	BF337	BF338
Maximum Voltages and Currents				
V_{CEO}	Collector to Emitter Voltage	180 V	200 V	225 V
V_{CBO}	Collector to Base Voltage	185 V	250 V	300 V
V_{EBO}	Emitter to Base Voltage	5.0 V	5.0 V	5.0 V
I_C	Continuous Collector Current	100 mA	100 mA	100 mA
Maximum Power Dissipation				
P_D	Total Dissipation @ 25°C Case Temperature			1.0 W
	Derate Linearly from 25°C			50 mW/°C
Maximum Temperatures				
T_J, T_{stg}	Storage and Operation Junction Temperatures			−65°C to +200°C
Thermal Characteristics				
$R_{\theta JC}$	Thermal Resistance, Junction to Case			20°C/W



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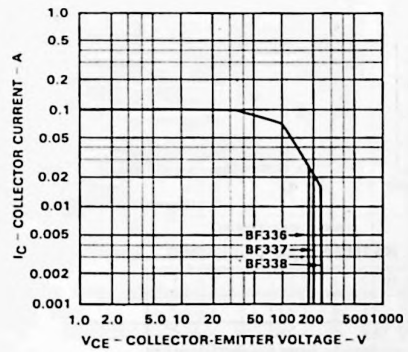
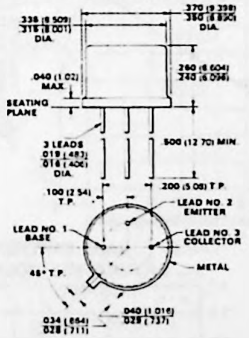
SAFE OPERATING AREA



JEDEC (TO-39) Outline



NOTES:
All dimensions in inches (bold) and millimeters (parentheses)
Leads are gold-plated kovar
Lead No. 3 connected to case
Package weight is 0.76 gram

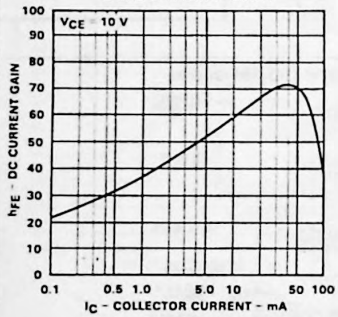
ELECTRICAL CHARACTERISTICS (25°C Case Temperature unless otherwise noted)

SYMBOL	CHARACTERISTIC	BF336		BF337		BF338		UNIT	TEST CONDITIONS
		MIN	MAX	MIN	MAX	MIN	MAX		
OFF CHARACTERISTICS									
$V_{CEO(sus)}$	Collector-Emitter Sustaining Voltage (Note 1)	180		200		225		V	I_C = 4.0 mA, I_B = 0
$V_{CER(sus)}$	Collector-Emitter Sustaining Voltage (Note 1)	185		250		300		V	I_C = 1.0 mA, R_{BE} = 1.0 KΩ, $T_A \leq 150°C$
V_{CBO}	Collector-Base Breakdown Voltage	185		250		300		V	I_C = 1.0 mA, I_E = 0
V_{EBO}	Emitter-Base Breakdown Voltage	5.0		5.0		5.0		V	I_E = 0.1 mA, I_C = 0
I_{CER}	Collector Cutoff Current		0.1		0.1		0.1	mA mA mA	V_{CE} = 150 V, R_{BE} = 1.0 KΩ V_{CE} = 200 V, R_{BE} = 1.0 KΩ V_{CE} = 250 V, R_{BE} = 1.0 KΩ
ON CHARACTERISTICS									
h_{FE}	DC Current Gain (Note 1)	20		20		20			I_C = 30 mA, V_{CE} = 10 V
$V_{BE(on)}$	Base-Emitter "On" Voltage (Note 1)		1.2		1.2		1.2	V	I_C = 30 mA, V_{CE} = 10 V
DYNAMIC CHARACTERISTICS									
f_T	Current-Gain-Bandwidth Product	50		50		50		MHz	I_C = 30 mA, V_{CE} = 20 V, f = 20 MHz
C_{re}	Common Emitter Reverse Transfer Capacitance		3.5		3.5		35.		V_{CE} = 20 V, I_C = 0, f = 0.5 MHz
r_b, C_c	Collector to Base Time Constant		100		100		100	ps	V_{CB} = 20 V, I_E = 30 mA, f = 10 MHz

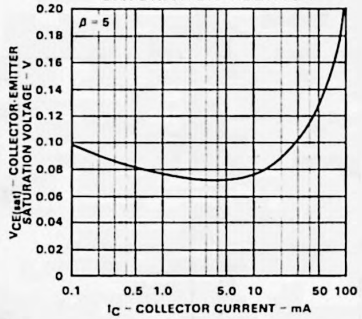
NOTE: 1. Pulse conditions: Length = 300 μs, Duty Cycle = 2%.

TYPICAL ELECTRICAL CHARACTERISTICS

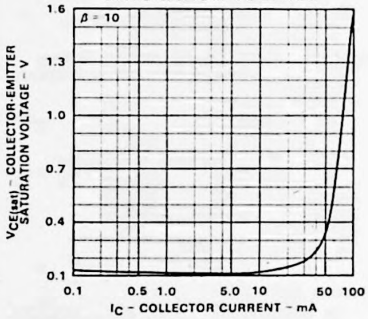
DC CURRENT GAIN



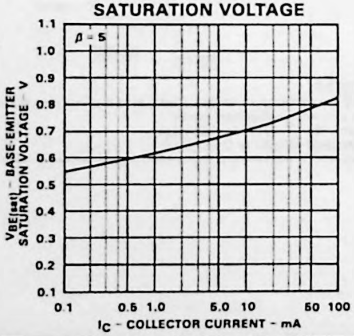
COLLECTOR-EMITTER SATURATION VOLTAGE



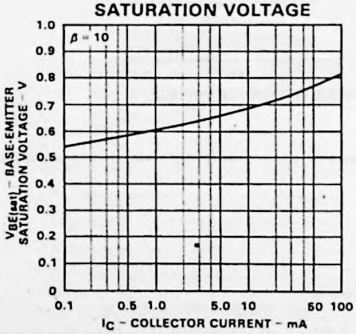
COLLECTOR-EMITTER SATURATION VOLTAGE



BASE-EMITTER SATURATION VOLTAGE



BASE-EMITTER SATURATION VOLTAGE



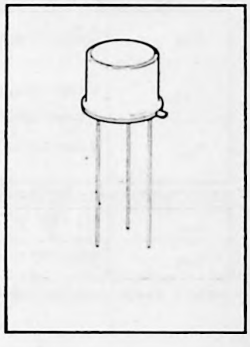
POWER TRANSISTOR

NPN SILICON

BFX34

HIGH CURRENT GENERAL PURPOSE DEVICE FOR EUROPEAN MARKET

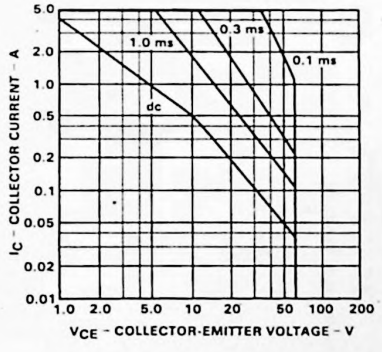
- 5.0 W DISSIPATION AT 25°C CASE
- 5.0 A MAXIMUM CONTINUOUS COLLECTOR CURRENT
- 40 – 150 h_{FE} AT I_C 2.0 A



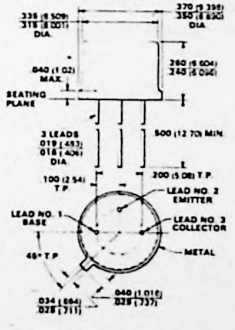
ABSOLUTE MAXIMUM RATINGS (Note 1)

		BFX34
Maximum Voltages and Currents		
V_{CEO}	Collector to Emitter Voltage	60 V
V_{CBO}	Collector to Base Voltage	120 V
V_{EBO}	Emitter to Base Voltage	6.0 V
I_C	Continuous Collector Current	5.0 A
Maximum Power Dissipation		
P_D	Total Dissipation @ 25°C Case Temperature	5.0 W
	Derate Linearly from 25°C	28.6 mW/°C
Maximum Temperatures		
T_J, T_{stg}	Storage and Operation Junction Temperatures	−55°C to +200°C
Thermal Characteristics		
$R_{\theta JC}$	Thermal Resistance, Junction to Case	35°C/W

SAFE OPERATING AREA



JEDEC (TO-39) Outline



NOTES:
All dimensions in inches (bold) and millimeters (parentheses)
Leads are gold-plated kovar
Lead No. 3 connected to case
Package weight is 1.23 grams

6

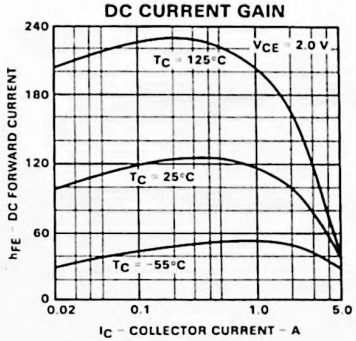
ELECTRICAL CHARACTERISTICS (25°C Case Temperature unless otherwise noted)

SYMBOL	CHARACTERISTIC	BFX34 MIN	BFX34 MAX	UNIT	TEST CONDITIONS
OFF CHARACTERISTICS					
$V_{CEO(sus)}$	Collector-Emitter Sustaining Voltage (Note 1)	60		V	I_C = 100 mA, I_B = 0
V_{CBO}	Collector-Base Breakdown Voltage	120		V	I_C = 5.0 mA, I_E = 0
V_{EBO}	Emitter-Base Breakdown Voltage	6.0		V	I_E = 1.0 mA, I_C = 0
I_{CES}	Collector Reverse Current		10	μA	V_{CE} = 60 V, V_{BE} = 0
I_{EBO}	Emitter Cutoff Current		10	μA	V_{EB} = 4.0 V, I_C = 0
ON CHARACTERISTICS					
h_{FE}	DC Current Gain (Note 1)	40 100 TYP 75 TYP	150		I_C = 2.0 A, V_{CE} = 2.0 V I_C = 1.0 A, V_{CE} = 2.0 V I_C = 1.5 A, V_{CE} = 2.0 V
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage (Note 1)		1.0	V	I_C = 5.0 A, I_B = 0.5 A
$V_{BE(sat)}$	Base-Emitter Saturation Voltage (Note 1)		1.6	V	I_C = 5.0 A, I_B = 0.5 A
DYNAMIC CHARACTERISTICS					
C_{ob}	Output Capacitance		100	pF	V_{CB} = 10 V, I_E = 0, f = 1.0 MHz
C_{TE}	Emitter-Transition Capacitance		400	pF	V_{EB} = 0.5 V, I_C = 0, f = 1.0 MHz
h_{fe}	Small Signal Current Gain	3.5			I_C = 0.5 A, V_{CE} = 5.0 V, f = 20 MHz
SWITCHING CHARACTERISTICS					
t_{on}	Turn On Time		0.6	μs	I_C = 5.0 A, I_{B1} = 5.0 A
t_{off}	Turn Off Time		1.2	μs	I_C = 5.0 A, I_{B1} = I_{B2} = 0.5 A

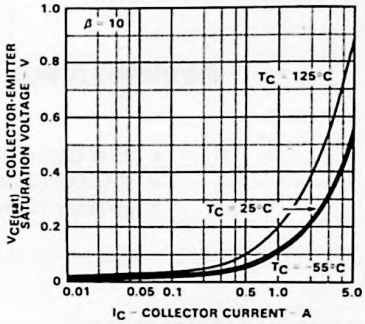
NOTE: 1. Pulse conditions: Length = 300 μs, Duty Cycle = 2%.

TYPICAL ELECTRICAL CHARACTERISTICS

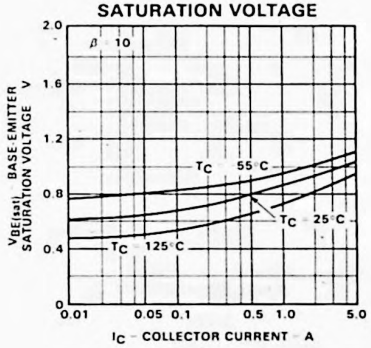
DC CURRENT GAIN



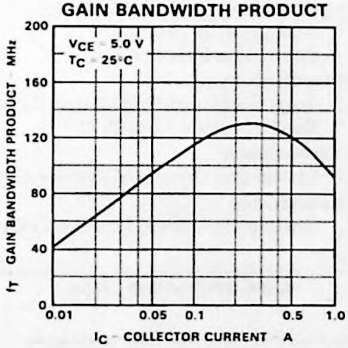
COLLECTOR-EMITTER SATURATION VOLTAGE



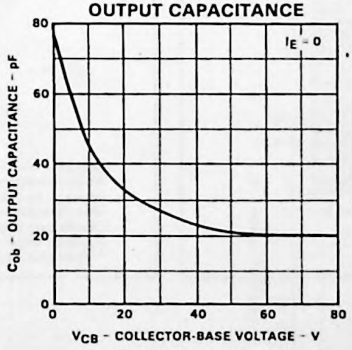
BASE-EMITTER SATURATION VOLTAGE



GAIN BANDWIDTH PRODUCT



OUTPUT CAPACITANCE



POWER TRANSISTOR

NPN SILICON

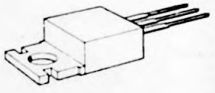
FT47
FT48
FT49
FT50

DESIGNED FOR HIGH VOLTAGE APPLICATIONS

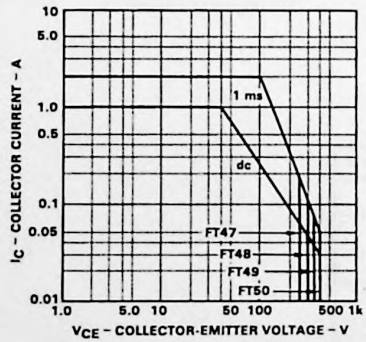
- 40 W DISSIPATION AT 25°C CASE
- 1 A MAXIMUM CONTINUOUS COLLECTOR CURRENT
- 250 MIN TO 400 V MIN V_{CEO}

ABSOLUTE MAXIMUM RATINGS (Note 1)

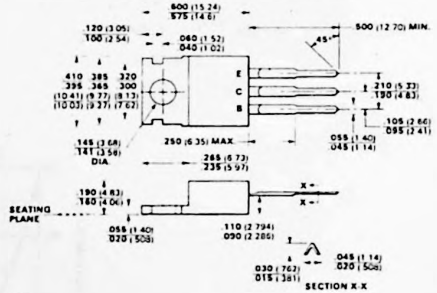
		FT47	FT48	FT49	FT50
Maximum Voltages and Currents					
V_{CEO}	Collector to Emitter Voltage	250 V	300 V	350 V	400 V
V_{CBO}	Collector to Base Voltage	350 V	400 V	450 V	500 V
V_{EBO}	Emitter to Base Voltage	5.0 V	5.0 V	5.0 V	5.0 V
I_C	Continuous Collector Current	1.0 A	1.0 A	1.0 A	1.0 A
I_C	Peak Collector Current	2.0 A	2.0 A	2.0 A	2.0 A
I_B	Continuous Base Current	0.6 A	0.6 A	0.6 A	0.6 A
Maximum Power Dissipation					
P_D	Total Dissipation @ 25°C Case Temperature				40 W
	Derate Linearly from 25°C				0.32 W/°C
Maximum Temperatures					
T_J, T_{stg}	Storage and Operation Junction Temperatures				−65°C to +150°C
Thermal Characteristics					
$R_{\theta JC}$	Thermal Resistance, Junction to Case				3.13°C/W



SAFE OPERATING AREA



JEDEC (TO-220) Outline**



NOTES:
All dimensions in inches (bold) and millimeters (parentheses)
Package is silicone plastic with nickel-plated copper tab and pins
*Mechanically interchangeable with TO-66
Center pin is electrical contact with the mounting tab
Package weight is 2.1 grams
**Available in various pin configurations

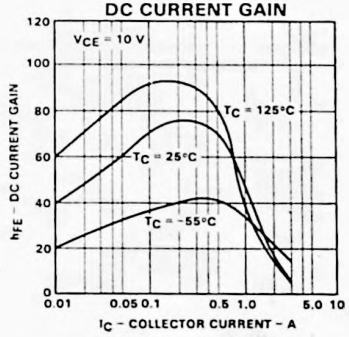
ELECTRICAL CHARACTERISTICS (25°C Case Temperature unless otherwise noted)

SYMBOL	CHARACTERISTIC	FT47		FT48		FT49		FT50		UNIT	TEST CONDITIONS
		MIN	MAX	MIN	MAX	MIN	MAX	MIN	MAX		
OFF CHARACTERISTICS											
$V_{CEO(sus)}$	Collector-Emitter Sustaining Voltage (Note 1)	250		300		350		400		V	I_C = 30 mA, I_B = 0
I_{CEO}	Collector Cutoff Current		1.0		1.0		1.0		1.0	mA mA mA mA	V_{CE} = 150 V, I_B = 0 V_{CE} = 200 V, I_B = 0 V_{CE} = 250 V, I_B = 0 V_{CE} = 300 V, I_B = 0
I_{CES}	Collector Reverse Current		1.0		1.0		1.0		1.0	mA mA mA mA	V_{CE} = 350 V, V_{BE} = 0 V_{CE} = 400 V, V_{BE} = 0 V_{CE} = 450 V, V_{BE} = 0 V_{CE} = 500 V, V_{BE} = 0
I_{EBO}	Emitter Cutoff Current		1.0		1.0		1.0		1.0	mA	V_{EB} = 5.0 V, I_C = 0
ON CHARACTERISTICS											
h_{FE}	DC Current Gain (Note 1)	30 10	150	30 10	150	30 10	150	30 10	150		I_C = 0.3 A, V_{CE} = 10 V I_C = 1.0 A, V_{CE} = 10 V
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage (Note 1)		1.0		1.0		1.0		1.0	V	I_C = 1.0 A, I_B = 0.2 A
$V_{BE(on)}$	Base-Emitter "On" Voltage (Note 1)		1.5		1.5		1.5		1.5	V	I_C = 1.0 A, V_{CE} = 10 V
DYNAMIC CHARACTERISTICS											
$\|h_{fe}\|$	Magnitude of Common Emitter Small Signal Current Gain	5.0		5.0		5.0		5.0			I_C = 0.2 A, V_{CE} = 10 V, f = 2.0 MHz
h_{fe}	Small Signal Current Gain	25		25		25		25			I_C = 0.2 A, V_{CE} = 10 V, f = 1.0 KHz

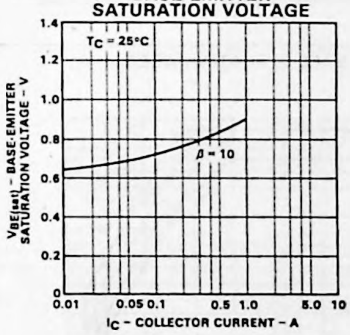
NOTE: 1. Pulse conditions: Length = 300 μs, Duty Cycle = 2%.

TYPICAL ELECTRICAL CHARACTERISTICS

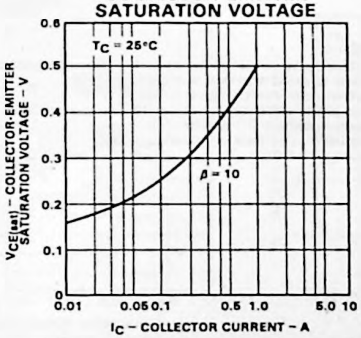
DC CURRENT GAIN

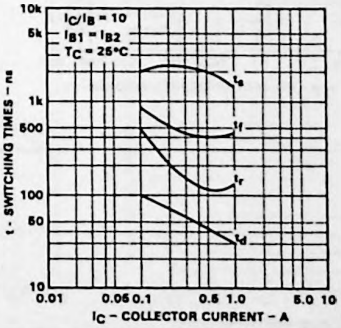


BASE-EMITTER SATURATION VOLTAGE



COLLECTOR-EMITTER SATURATION VOLTAGE





POWER TRANSISTOR

NPN SILICON

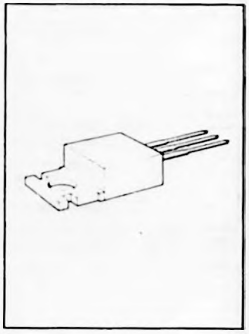
FT317
FT317A
FT317B

DESIGNED FOR HIGH FREQUENCY DRIVER IN AUDIO AMPLIFIERS

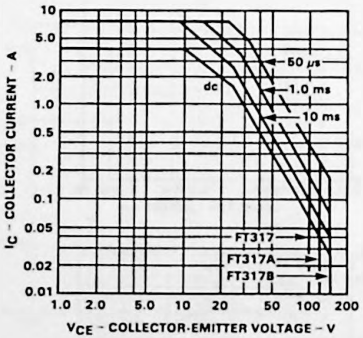
- 40 W DISSIPATION AT 25°C CASE
- 4.0 A MAXIMUM CONTINUOUS COLLECTOR CURRENT
- 35 MINIMUM h_{FE} @ 1.0 A
- COMPLEMENT TO FT417, FT417A, FT417B

ABSOLUTE MAXIMUM RATINGS (Note 1)

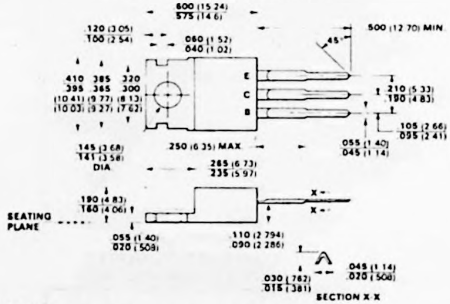
		FT317	FT317A	FT317B
Maximum Voltages and Currents				
V_{CEO}	Collector to Emitter Voltage	100 V	120 V	140 V
V_{CBO}	Collector to Base Voltage	100 V	120 V	140 V
V_{EBO}	Emitter to Base Voltage	5.0 V	5.0 V	5.0 V
I_C	Continuous Collector Current	4.0 A	4.0 A	4.0 A
I_C	Peak Collector Current	8.0 A	8.0 A	8.0 A
I_B	Continuous Base Current	2.0 A	2.0 A	2.0 A
Maximum Power Dissipation				
P_D	Total Dissipation @ 25°C Case Temperature			40 W
	Derate Linearly from 25°C			0.32 W/°C
Maximum Temperatures				
T_J, T_{stg}	Storage and Operation Junction Temperatures			−65°C to +150°C
Thermal Characteristics				
$R_{\theta JC}$	Thermal Resistance, Junction to Case			3.13°C/W



SAFE OPERATING AREA



JEDEC (TO-220) Outline**



NOTES:
All dimensions in inches (bold) and millimeters (parentheses)
Package is silicone plastic with nickel-plated copper tab and pins
*Mechanically interchangeable with TO-66
Center pin is electrical contact with the mounting tab
Package weight is 2.1 grams
**Available in various pin configurations

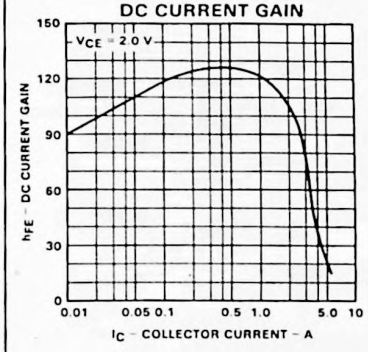
ELECTRICAL CHARACTERISTICS (25°C Case Temperature unless otherwise noted)

SYMBOL	CHARACTERISTIC	FT317		FT317A		FT317B		UNIT	TEST CONDITIONS
		MIN	MAX	MIN	MAX	MIN	MAX		
OFF CHARACTERISTICS									
$V_{CEO(sus)}$	Collector-Emitter Sustaining Voltage (Note 1)	100		120		140		V	I_C = 10 mA, I_B = 0
I_{CEO}	Collector Cutoff Current		0.5		0.5		0.5	mA mA mA	V_{CE} = 100 V, I_B = 0 V_{CE} = 120 V, I_B = 0 V_{CE} = 140 V, I_B = 0
I_{CBO}	Collector Cutoff Current		0.01		0.01		0.01	mA mA mA	V_{CB} = 100 V, I_E = 0 V_{CB} = 120 V, I_E = 0 V_{CB} = 140 V, I_E = 0
I_{EBO}	Emitter Cutoff Current		0.1		0.1		0.1	mA	V_{EB} = –5.0 V, I_C = 0
ON CHARACTERISTICS									
h_{FE}	DC Current Gain (Note 1)	35 20		35 20		35 20			I_C = 1.0 A, V_{CE} = 2.0 V I_C = 3.0 A, V_{CE} = 2.0 V
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage (Note 1)		0.5		0.5		0.5	V	I_C = 1.0 A, I_B = 0.1 A
$V_{BE(on)}$	Base-Emitter "On" Voltage (Note 1)		1.0		1.0		1.0	V	I_C = 1.0 A, V_{CE} = 2.0 V
DYNAMIC CHARACTERISTICS									
f_T	Current-Gain-Bandwidth Product	20		20		20		MHz	I_C = 200 mA, V_{CE} = 10 V, f = 10 MHz
C_{ob}	Output Capacitance		100		100		100	pF	V_{CB} = 20 V, I_E = 0, f = 1.0 MHz

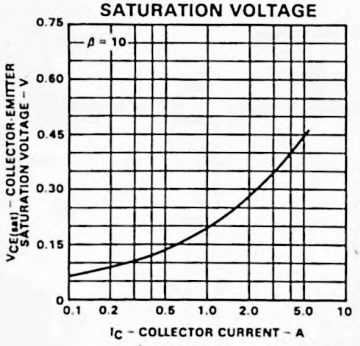
NOTE: 1. Pulse conditions: Length = 300 μs, Duty Cycle = 2%.

TYPICAL ELECTRICAL CHARACTERISTICS

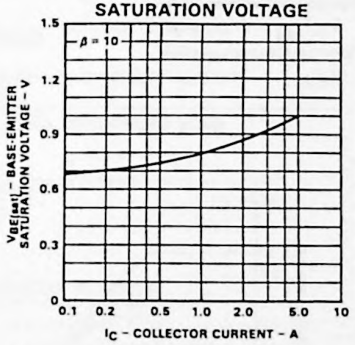
DC CURRENT GAIN



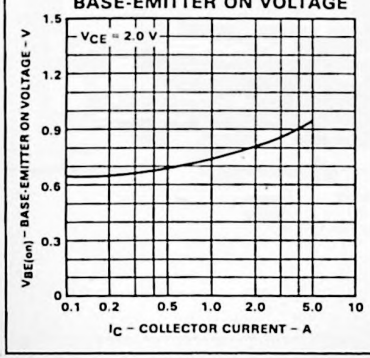
COLLECTOR-EMITTER SATURATION VOLTAGE



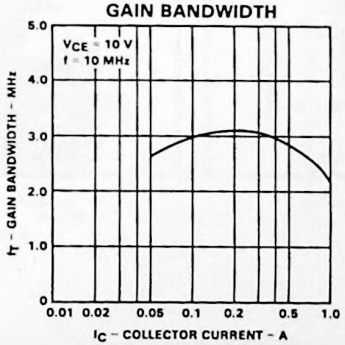
BASE-EMITTER SATURATION VOLTAGE



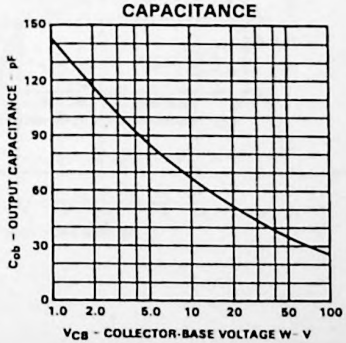
BASE-EMITTER ON VOLTAGE



GAIN BANDWIDTH



CAPACITANCE

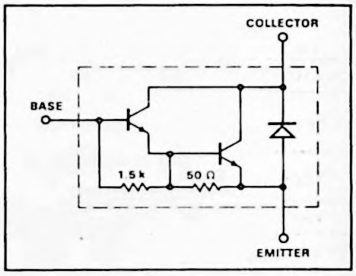


POWER DARLINGTON

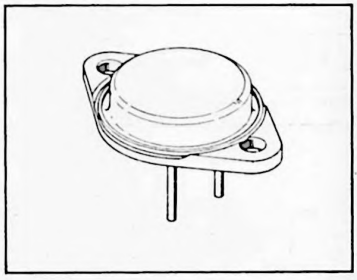
NPN SILICON

FT359

HIGH VOLTAGE, HIGH CURRENT DARLINGTON DEVELOPED FOR IGNITION (COIL DRIVER) APPLICATIONS



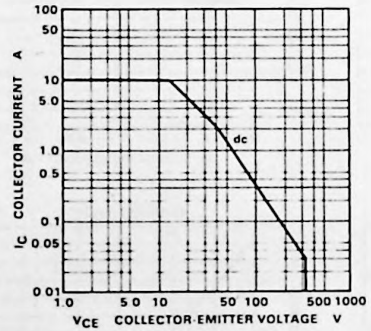
- 125 W DISSIPATION AT 25°C CASE
- 10 A MAXIMUM CONTINUOUS COLLECTOR CURRENT
- 350 V V_{CEO}



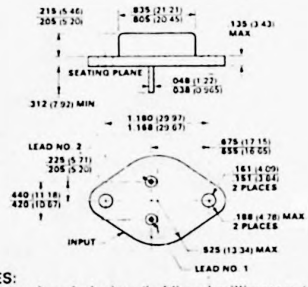
ABSOLUTE MAXIMUM RATINGS (note 1)

Maximum Voltages and Currents		
V_{CEO}	Collector to Emitter Voltage	350 V
V_{CBO}	Collector to Base Voltage	375 V
V_{EBO}	Emitter to Base Voltage	5.0 V
I_C	Continuous Collector Current	10 A
I_C	Peak Collector Current	15 A
I_B	Continuous Base Current	2.0 A
Maximum Power Dissipation		
P_D	Total Dissipation @ 25°C Case Temperature	125 W
	Derate Linearly from 25°C	1.0 W/°C
Maximum Temperatures		
T_J, T_{stg}	Storage and Operation Junction Temperatures	−65°C to +150°C
Thermal Characteristics		
$R_{\theta JC}$	Thermal Resistance, Junction to Case	1.0°C/W

SAFE OPERATING AREA



JEDEC (TO-3) Outline



NOTES:
All dimensions in inches (bold) and millimeters (parentheses)
Pins are gold-plated or solder-dipped alloy 52
Pins 1 and 2 electrically isolated from case
Case is third electrical connection
Aluminum package with copper slug, pins are soldered in
Package weight is 7.4 grams
Aluminum cap

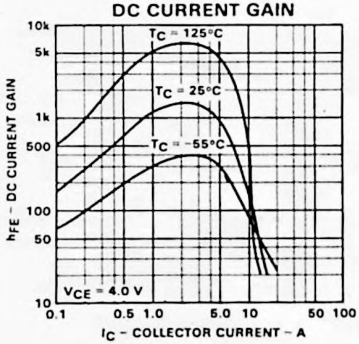
ELECTRICAL CHARACTERISTICS (25°C Case Temperature unless otherwise noted)

SYMBOL	CHARACTERISTIC	FT359 MIN	FT359 MAX	UNIT	TEST CONDITIONS
OFF CHARACTERISTICS					
$V_{CEO(sus)}$	Collector-Emitter Sustaining Voltage (Note 1)	350		V	I_C = 200 mA, I_B = 0
V_{CER}	Collector-Emitter Breakdown Voltage (Note 1)	350		V	I_C = 200 mA, R_{BE} = 100 Ω
I_{CEO}	Collector Cutoff Current		3.0	mA	V_{CE} = 375 V, I_B = 0
I_{CEV}	Collector Cutoff Current		5.0	mA	V_{CE} = 375 V, V_{BE} = −1.5 V
I_{CER}	Collector Cutoff Current		2.0	mA	V_{CE} = 375 V, R_{BE} = 100 Ω
I_{EBO}	Emitter Cutoff Current		10	mA	V_{EB} = 5.0 V, I_C = 0
ON CHARACTERISTICS					
h_{FE}	DC Current Gain (Note 1)	250			I_C = 3.0 A, V_{CE} = 3.0 V
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage (Note 1)		2.5	V	I_C = 7.0 A, I_B = 140 mA
$V_{BE(sat)}$	Base-Emitter Saturation Voltage (Note 1)		2.8	V	I_C = 7.0 A, I_B = 140 mA

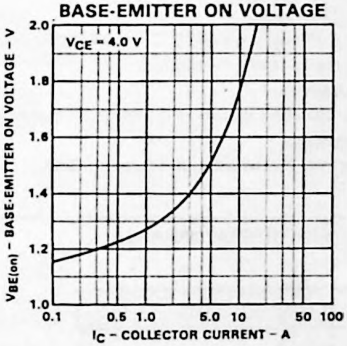
NOTE: 1. Pulse conditions: Length = 300 μs, Duty Cycle = 2%.

TYPICAL ELECTRICAL CHARACTERISTICS

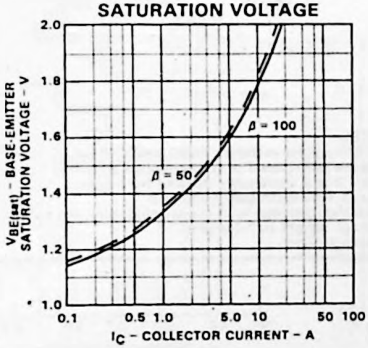
DC CURRENT GAIN



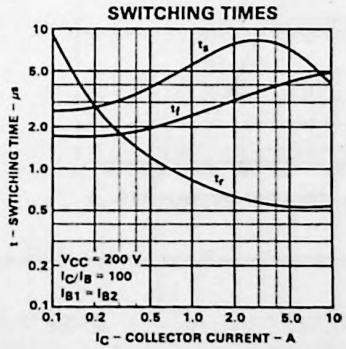
BASE-EMITTER ON VOLTAGE



BASE-EMITTER SATURATION VOLTAGE



SWITCHING TIMES



POWER TRANSISTOR

NPN SILICON

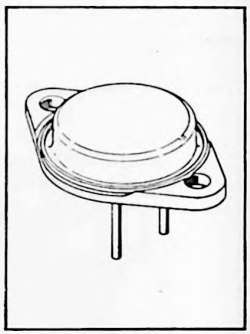
FT401
FT402

HIGH VOLTAGE, HIGH POWER DEVICES SPECIFICALLY DESIGNED FOR IGNITION SYSTEMS AND HIGH VOLTAGE APPLICATIONS REQUIRING RUGGED SOA CHARACTERISTICS

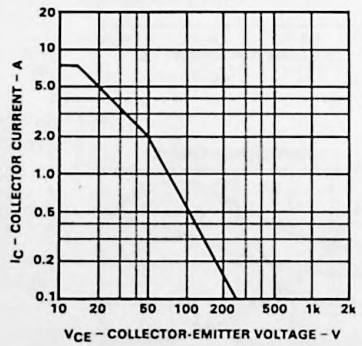
- 100 W DISSIPATION AT 25°C CASE
- 3.5 A MAXIMUM CONTINUOUS COLLECTOR CURRENT (FT402)
- 0.5 mA MAX I_{CEO} AT 400 V

ABSOLUTE MAXIMUM RATINGS (Note 1)

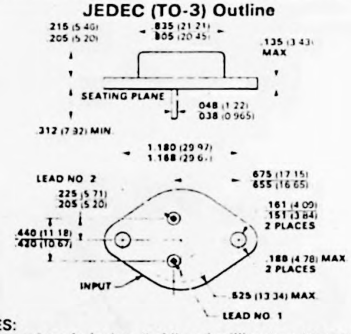
		FT401	FT402
Maximum Voltage and Currents			
V_{CEO}	Collector to Emitter Voltage	400 V	400 V
V_{EBO}	Emitter to Base Voltage	5.0 V	5.0 V
I_C	Continuous Collector Current	2.0 A	2.0 A
I_B	Continuous Base Current	1.0 A	1.0 A
Maximum Power Dissipation			
P_D	Total Dissipation @ 25°C Case Temperature		100 W
	Derate Linearly from 25°C		0.57 W/°C
Maximum Temperatures			
T_J, T_{stg}	Storage and Operation Junction Temperatures		−65°C to +200°C
Thermal Characteristics			
$R_{\theta JC}$	Thermal Resistance, Junction to Case		1.75°C/W



SAFE OPERATING AREA



JEDEC (TO-3) Outline



NOTES:
All dimensions in inches (bold) and millimeters (parentheses)
Pins are gold-plated or solder-dipped alloy 52
Pins 1 and 2 electrically isolated from case
Case is third electrical connection
Aluminum package with copper slug, pins are soldered in
Package weight is 7.4 grams
Aluminum cap

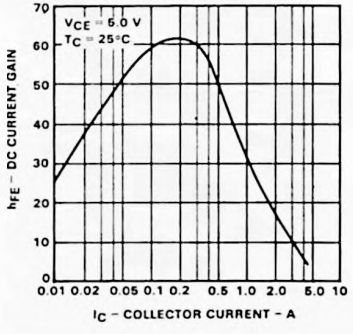
ELECTRICAL CHARACTERISTICS (25°C Case Temperature unless otherwise noted)

SYMBOL	CHARACTERISTIC	FT401		FT402		UNIT	TEST CONDITIONS
		MIN	MAX	MIN	MAX		
OFF CHARACTERISTICS							
$V_{CEO(sus)}$	Collector-Emitter Sustaining Voltage (Note 1)	300		325		V	I_C = 100 mA, I_B = 0
I_{CEO}	Collector Cutoff Current		0.5		0.5	mA	V_{CE} = 400 V, I_B = 0
I_{CEX}	Collector Cutoff Current		0.5		0.5	mA	V_{CE} = 400 V, V_{BE} = −1.5 V
I_{EBO}	Emitter Cutoff Current		5.0		5.0	mA	V_{EB} = 5.0 V, I_C = 0
ON CHARACTERISTICS							
h_{FE}	DC Current Gain (Note 1)	20	100	20	100		I_C = 0.5 A, V_{CE} = 5.0 V
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage (Note 1)		0.8			V	I_C = 0.5 A, I_B = 0.05 A
					2.0	V	I_C = 3.0 A, I_B = 0.6 A
$V_{BE(sat)}$	Base-Emitter Saturation Voltage (Note 1)		1.5		1.5	V	I_C = 3.0 A, I_B = 0.6 A
DYNAMIC CHARACTERISTICS							
f_T	Current-Gain-Bandwidth Product	2.0		2.0		MHz	I_C = 0.5 A, V_{CE} = 5.0 V, f = 1.0 MHz

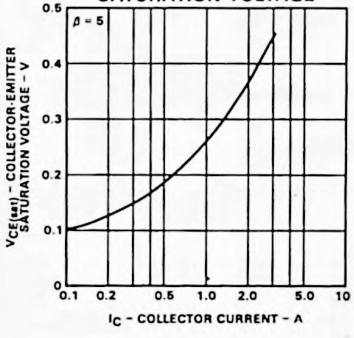
NOTE: 1. Pulse conditions: Length = 300 μs, Duty Cycle = 2%.

TYPICAL ELECTRICAL CHARACTERISTICS

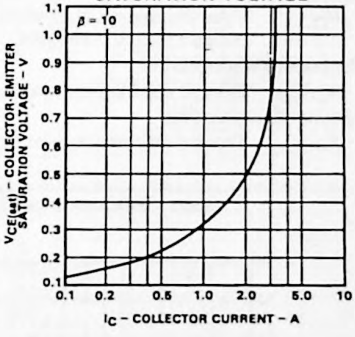
DC CURRENT GAIN



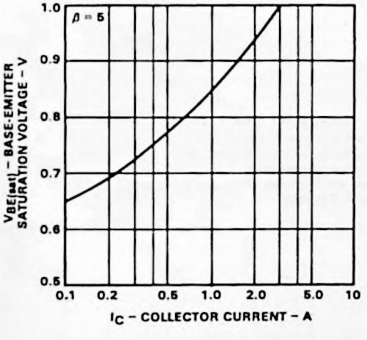
COLLECTOR-EMITTER SATURATION VOLTAGE



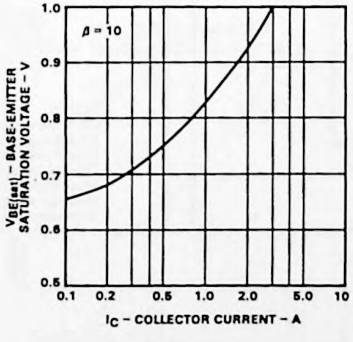
COLLECTOR-EMITTER SATURATION VOLTAGE



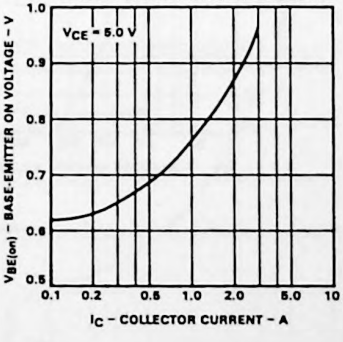
BASE-EMITTER SATURATION VOLTAGE



BASE-EMITTER SATURATION VOLTAGE



BASE-EMITTER ON VOLTAGE



6

POWER TRANSISTOR

NPN SILICON

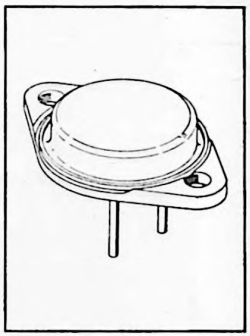
FT410
FT411

HIGH VOLTAGE, HIGH POWER DEVICES SPECIFICALLY DESIGNED FOR IGNITION SYSTEMS AND HIGH VOLTAGE APPLICATIONS REQUIRING RUGGED SOA CHARACTERISTICS

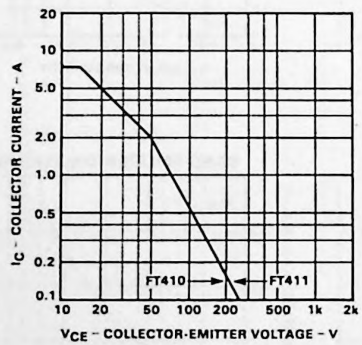
- 100 W DISSIPATION AT 25°C CASE
- 7.5 A MAXIMUM CONTINUOUS COLLECTOR CURRENT
- 0.25 mA MAX I_{CEO} AT 300 V (FT411)

ABSOLUTE MAXIMUM RATINGS (Note 1)

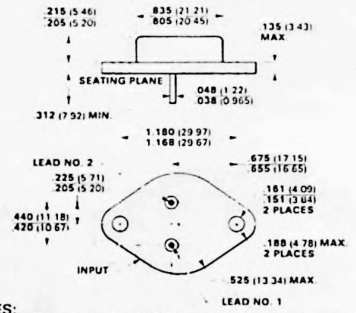
		FT410	FT411
Maximum Voltages and Currents			
V_{CEO}	Collector to Emitter Voltage	200 V	300 V
V_{CBO}	Collector to Base Voltage	5.0 V	5.0 V
I_C	Continuous Collector Current	7.5 A	7.5 A
I_B	Continuous Base Current	3.75 A	3.75 A
Maximum Power Dissipation			
P_D	Total Dissipation @ 25°C Case Temperature		100 W
	Derate Linearly from 25°C		0.57 W/°C
Maximum Temperatures			
T_J, T_{stg}	Storage and Operation Junction Temperatures		−65°C to +200°C
Thermal Characteristics			
$R_{\theta JC}$	Thermal Resistance, Junction to Case		1.75°C/W



SAFE OPERATING AREA



JEDEC (TO-3) Outline



NOTES:
All dimensions in inches (bold) and millimeters (parentheses)
Pins are gold-plated or solder-dipped alloy 52
Pins 1 and 2 electrically isolated from case
Case is third electrical connection
Aluminum package with copper slug, pins are soldered in
Package weight is 7.4 grams
Aluminum cap

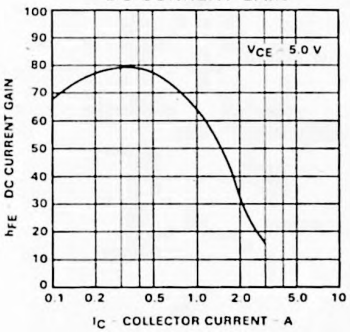
ELECTRICAL CHARACTERISTICS (25°C Case Temperature unless otherwise noted)

SYMBOL	CHARACTERISTIC	FT410		FT411		UNIT	TEST CONDITIONS
		MIN	MAX	MIN	MAX		
OFF CHARACTERISTICS							
$V_{CEO(sus)}$	Collector-Emitter Sustaining Voltage (Note 1)	200		300		V	I_C = 100 mA, I_B = 0
I_{CEO}	Collector Cutoff Current		0.25			mA	V_{CE} = 200 V, I_B = 0
					0.25	mA	V_{CE} = 300 V, I_B = 0
I_{CEX}	Collector Cutoff-Current		0.5		0.5	mA	V_{CEX} = 300 V, V_{BE} = −1.5 V, T_C = 125°C
I_{EBO}	Emitter Cutoff Current		5.0		5.0	mA	V_{EB} = 5.0 V, I_C = 0
ON CHARACTERISTICS							
h_{FE}	DC Current Gain (Note 1)	30	90	30	90		I_C = 1.0 A, V_{CE} = 5.0 V
		10		10			I_C = 2.5 A, V_{CE} = 5.0 V
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage (Note 1)		0.8		0.8	V	I_C = 1.0 A, I_B = 0.1 A
			5.0		5.0	V	I_C = 7.5 A, I_B = 3.75 A
$V_{BE(sat)}$	Base-Emitter Saturation Voltage (Note 1)		1.5		1.5	V	I_C = 1.0 A, I_B = 0.1 A
DYNAMIC CHARACTERISTICS							
f_T	Current-Gain-Bandwidth Product	5.0		5.0		MHz	I_C = 0.2 A, V_{CE} = 5.0 V, f = 1.0 MHz

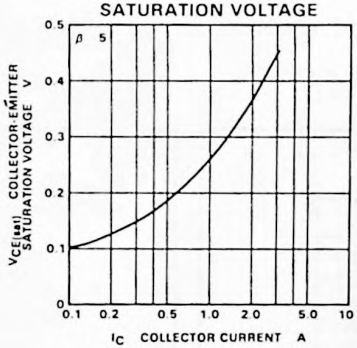
NOTE: 1. Pulse conditions: Length = 300 μs, Duty Cycle = 2%.

TYPICAL ELECTRICAL CHARACTERISTICS

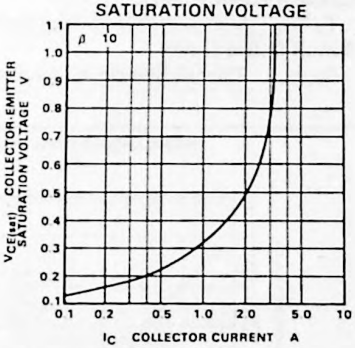
DC CURRENT GAIN



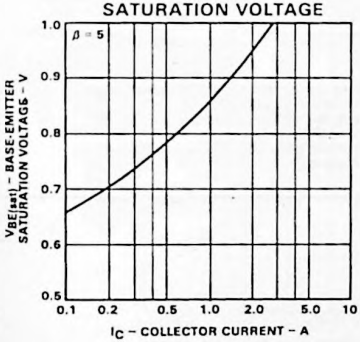
COLLECTOR-EMITTER SATURATION VOLTAGE



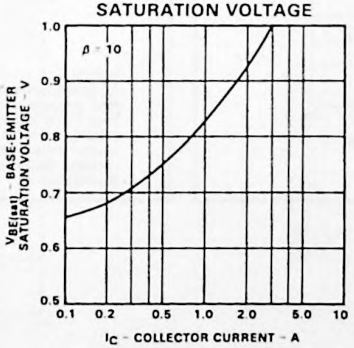
COLLECTOR-EMITTER SATURATION VOLTAGE



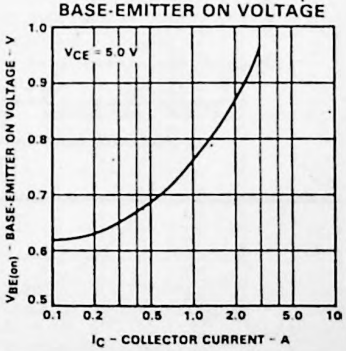
BASE-EMITTER SATURATION VOLTAGE



BASE-EMITTER SATURATION VOLTAGE



BASE-EMITTER ON VOLTAGE



POWER TRANSISTOR

NPN SILICON

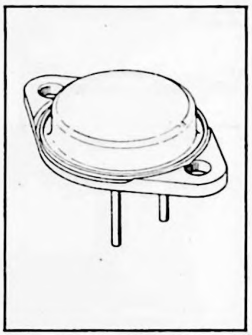
FT413
FT423

HIGH POWER, HIGH VOLTAGE DEVICE DESIGNED SPECIFICALLY FOR AUTO IGNITION SYSTEMS

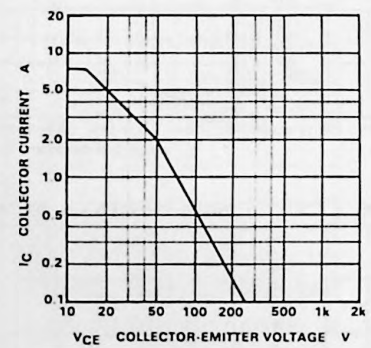
- 100 W DISSIPATION AT 25°C CASE
- 7.5 A MAXIMUM CONTINUOUS COLLECTOR CURRENT

ABSOLUTE MAXIMUM RATINGS (Note 1)

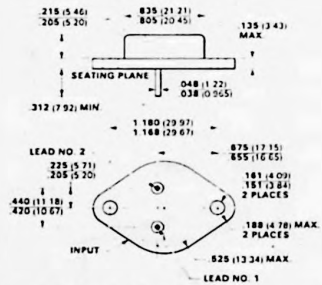
		FT413	FT423
Maximum Voltages and Currents			
V_{CEO}	Collector to Emitter Voltage	400 V	400 V
V_{EBO}	Emitter to Base Voltage	5.0 V	5.0 V
I_C	Continuous Collector Current	7.5 A	7.5 A
I_B	Continuous Base Current	3.75 A	3.75 A
Maximum Power Dissipation			
P_D	Total Dissipation @ 25°C Case Temperature		100 W
	Derate Linearly from 25°C		0.57 W/°C
Maximum Temperatures			
T_J, T_{stg}	Storage and Operation Junction Temperatures		−65°C to +200°C
Thermal Characteristics			
$R_{\theta JC}$	Thermal Resistance, Junction to Case		1.75 W/°C



SAFE OPERATING AREA



JEDEC (TO-3) Outline



NOTES:
All dimensions in inches (bold) and millimeters (parentheses)
Pins are gold-plated or solder-dipped alloy 52
Pins 1 and 2 electrically isolated from case
Case is third electrical connection
Aluminum package with copper slug, pins are soldered in
Package weight is 7.4 grams
Aluminum cap

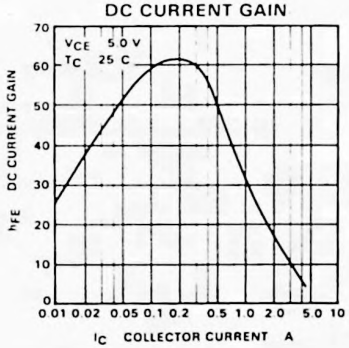
ELECTRICAL CHARACTERISTICS (25°C Case Temperature unless otherwise noted)

SYMBOL	CHARACTERISTIC	FT413		FT423		UNIT	TEST CONDITIONS
		MIN	MAX	MIN	MAX		
OFF CHARACTERISTICS							
$V_{CEO(sus)}$	Collector-Emitter Sustaining Voltage (Note 1)	325		325		V	I_C = 100 mA, I_B = 0
I_{CEO}	Collector Cutoff Current		0.25		0.25	mA	V_{CE} = 400 V, I_B = 0
I_{CEX}	Collector Cutoff Current		0.5		0.5	mA	V_{CE} = 400 V, V_{BE} = −1.5 V, T_C = 125°C
I_{EBO}	Emitter Cutoff Current		5.0		5.0	mA	V_{EB} = 5.0 V, I_C = 0
ON CHARACTERISTICS							
h_{FE}	DC Current Gain (Note 1)	20	80	30	90		I_C = 0.5 A, V_{CE} = 5.0 V
		15					I_C = 1.0 A, V_{CE} = 5.0 V
				10			I_C = 1.0 A, V_{CE} = 5.0 V
							I_C = 2.5 A, V_{CE} = 5.0 V
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage (Note 1)		0.8			V	I_C = 0.5 A, I_B = 0.05 A
					0.8	V	I_C = 1.0 A, I_B = 0.1 A
			5.0		5.0	V	I_C = 7.5 A, I_B = 3.75 A
$V_{BE(sat)}$	Base-Emitter Saturation Voltage (Note 1)		1.5			V	I_C = 0.5 A, I_B = 0.05 A
					1.5	V	I_C = 1.0 A, I_B = 0.1 A
DYNAMIC CHARACTERISTICS							
f_T	Current-Gain-Bandwidth Product	5.0 TYP		5.0 TYP		MHz	I_C = 0.2 A, V_{CE} = 5.0 V, f = 1.0 MHz

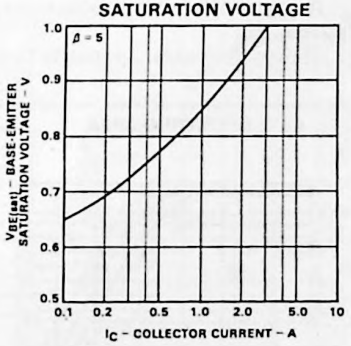
NOTE: 1. Pulse conditions: Length = 300 μs, Duty Cycle = 2%.

TYPICAL ELECTRICAL CHARACTERISTICS

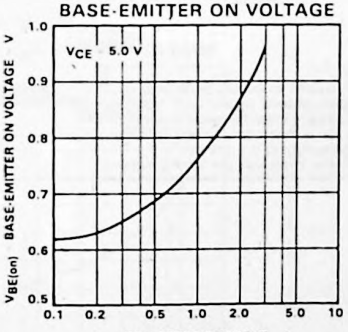
DC CURRENT GAIN



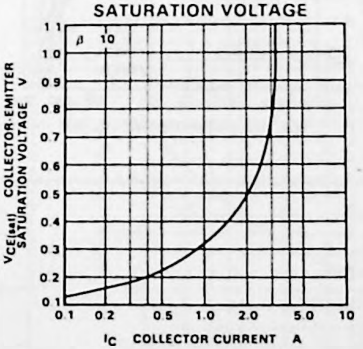
BASE-EMITTER SATURATION VOLTAGE



BASE-EMITTER ON VOLTAGE



COLLECTOR-EMITTER SATURATION VOLTAGE



POWER TRANSISTOR

PNP SILICON

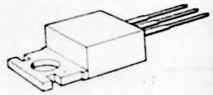
FT417
FT417A
FT417B

DESIGNED FOR HIGH FREQUENCY DRIVER IN AUDIO AMPLIFIERS

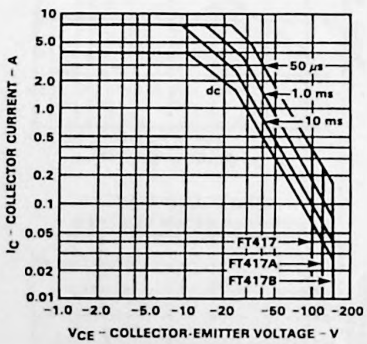
- 40 W DISSIPATION AT 25°C CASE
- 4.0 A MAXIMUM CONTINUOUS COLLECTOR CURRENT
- 35 MINIMUM h_{FE} @ 1.0 A
- COMPLEMENT TO FT317, FT317A, FT317B

ABSOLUTE MAXIMUM RATINGS (Note 1)

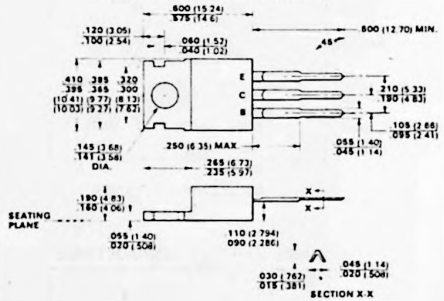
		FT417	FT417A	FT417B
Maximum Voltages and Currents				
V_{CEO}	Collector to Emitter Voltage	−100 V	−120 V	−140 V
V_{CBO}	Collector to Base Voltage	−100 V	−120 V	−140 V
V_{EBO}	Emitter to Base Voltage	−5.0 V	−5.0 V	−5.0 V
I_C	Continuous Collector	4.0 A	4.0 A	4.0 A
I_C	Peak Collector Current	8.0 A	8.0 A	8.0 A
I_B	Continuous Base Current	2.0 A	2.0 A	2.0 A
Maximum Power Dissipation				
P_D	Total Dissipation @ 25°C Case Temperature			40 W
	Derate Linearly from 25°C			0.32 W/°C
Maximum Temperatures				
T_J, T_{stg}	Storage and Operation Junction Temperatures			−65°C to +150°C
Thermal Characteristics				
$R_{\theta JC}$	Thermal Resistance, Junction to Case			3.13°C/W



SAFE OPERATING AREA



JEDEC (TO-220) Outline**



NOTES:
All dimensions in inches (bold) and millimeters (parentheses)
Package is silicone plastic with nickel-plated copper tab and pins
*Mechanically interchangeable with TO-66
Center pin is electrical contact with the mounting tab
Package weight is 2.1 grams
**Available in various pin configurations

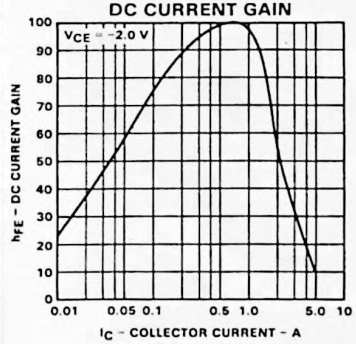
ELECTRICAL CHARACTERISTICS (25°C Case Temperature unless otherwise noted)

SYMBOL	CHARACTERISTIC	FT417		FT417A		FT417B		UNIT	TEST CONDITIONS
		MIN	MAX	MIN	MAX	MIN	MAX		
OFF CHARACTERISTICS									
$V_{CEO(sus)}$	Collector-Emitter Sustaining Voltage (Note 1)	−100		−120		−140		V	I_C = 10 mA, I_B = 0
I_{CEO}	Collector Cutoff Current		0.5		0.5			mA	V_{CE} = −100 V, I_B = 0
								mA	V_{CE} = −120 V, I_B = 0
							0.5	mA	V_{CE} = −140 V, I_B = 0
I_{CBO}	Collector Cutoff Current		0.01		0.01			mA	V_{CB} = −100 V, I_E = 0
								mA	V_{CB} = −120 V, I_E = 0
							0.01	mA	V_{CB} = −140 V, I_E = 0
I_{EBO}	Emitter Cutoff Current		0.1		0.1		0.1	mA	V_{EB} = −5.0 V, I_C = 0
ON CHARACTERISTICS									
h_{FE}	DC Current Gain (Note 1)	35		35		35			I_C = 1.0 A, V_{CE} = −2.0 V
		20		20		20			I_C = 3.0 A, V_{CE} = −2.0 V
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage (Note 1)		−0.5		−0.5		−0.5	V	I_C = 1.0 A, I_B = 0.1 A
$V_{BE(on)}$	Base-Emitter "On" Voltage (Note 1)		−1.0		−1.0		−1.0	V	I_C = 1.0 A, V_{CE} = −2.0 V
DYNAMIC CHARACTERISTICS									
f_T	Current-Gain-Bandwidth Product	20		20		20		MHz	I_C = 200 mA, V_{CE} = −10 V, f = 10 MHz
C_{ob}	Output Capacitance		100		100		100	pF	V_{CB} = −20 V, I_E = 0, f = 1.0 MHz

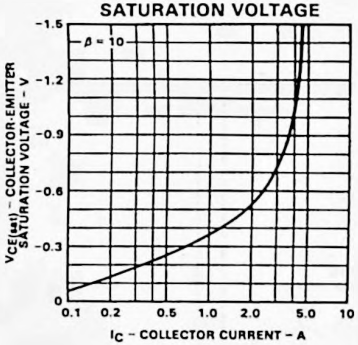
NOTE: 1. Pulse conditions: Length = 300 μs, Duty Cycle = 2%.

TYPICAL ELECTRICAL CHARACTERISTICS

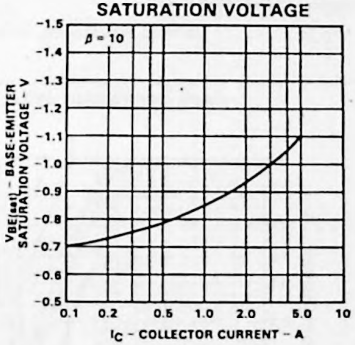
DC CURRENT GAIN



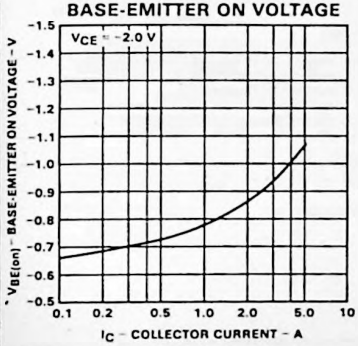
COLLECTOR-EMITTER SATURATION VOLTAGE



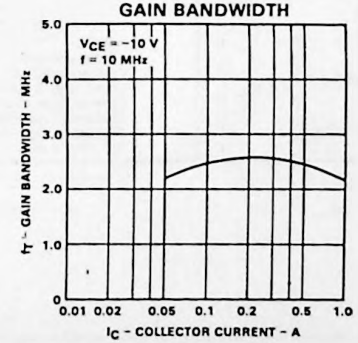
BASE-EMITTER SATURATION VOLTAGE



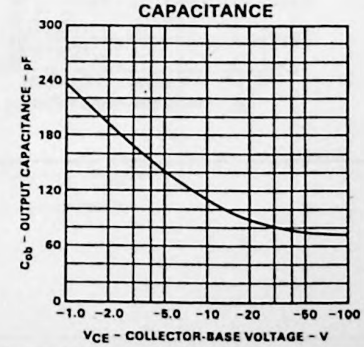
BASE-EMITTER ON VOLTAGE



GAIN BANDWIDTH



CAPACITANCE



POWER TRANSISTOR

NPN SILICON

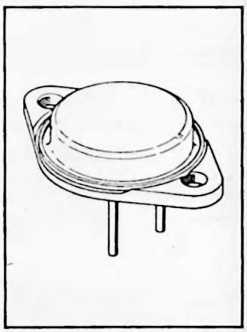
FT430
FT431

SUITABLE FOR USE IN INVERTERS, DEFLECTION CIRCUITS, SWITCHING REGULATORS AND IGNITION CIRCUITS

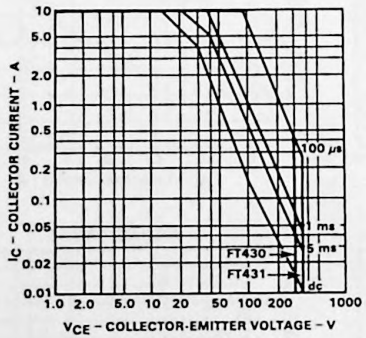
- 125 W DISSIPATION AT 25°C CASE
- 10 A MAXIMUM CONTINUOUS COLLECTOR CURRENT
- 400 V V_{CEO}

ABSOLUTE MAXIMUM RATINGS (Note 1)

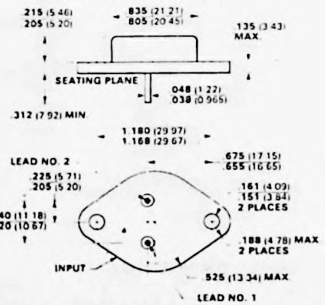
		FT430	FT431
Maximum Voltages and Currents			
V_{CEO}	Collector to Emitter Voltage	400 V	400 V
V_{EBO}	Emitter to Base Voltage	5.0 V	5.0 V
I_C	Continuous Collector Current	10 A	10 A
I_B	Continuous Base Current	5.0 A	5.0 A
Maximum Power Dissipation			
P_D	Total Dissipation @ 25°C Case Temperature		125 W
	Derate Linearly from 25°C		0.71 W/°C
Maximum Temperatures			
T_J, T_{stg}	Storage and Operation Junction Temperatures		−65°C to +200°C
Thermal Characteristics			
$R_{\theta JC}$	Thermal Resistance, Junction to Case		1.4°C/W



SAFE OPERATING AREA



JEDEC (TO-3) Outline



NOTES:
All dimensions in inches (bold) and millimeters (parentheses)
Pins are gold-plated or solder-dipped alloy 52
Pins 1 and 2 electrically isolated from case
Case is third electrical connection
Aluminum package with copper slug, pins are soldered in
Package weight is 7.4 grams
Aluminum cap

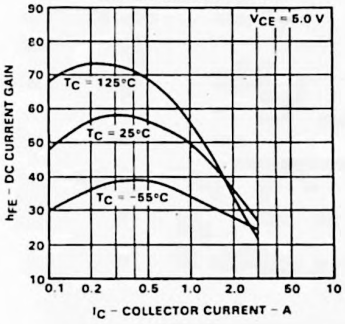
ELECTRICAL CHARACTERISTICS (25°C Case Temperature unless otherwise noted)

SYMBOL	CHARACTERISTIC	FT430		FT431		UNIT	TEST CONDITIONS
		MIN	MAX	MIN	MAX		
OFF CHARACTERISTICS							
$V_{CEO(sus)}$	Collector-Emitter Sustaining Voltage (Note 1)	300		325		V	I_C = 100 mA, I_B = 0
I_{CEO}	Collector Cutoff Current		2.5		2.5	mA	V_{CE} = 400 V, I_B = 0
I_{CEX}	Collector Cutoff Current		5.0		5.0	mA	V_{CE} = 400 V, V_{BE} = −1.5 V T_C = 125°C
I_{EBO}	Emitter Cutoff Current		5.0		5.0	mA	V_{EB} = 5.0 V, I_C = 0
ON CHARACTERISTICS							
h_{FE}	DC Current Gain (Note 1)	15 10	45	15 10	35		I_C = 2.5 A, V_{CE} = 5.0 V I_C = 3.5 A, V_{CE} = 5.0 V
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage (Note 1)		0.9 5.0		0.7 5.0	V V	I_C = 2.5 A, I_B = 0.5 A I_C = 10 A, I_B = 5.0 A
$V_{BE(sat)}$	Base-Emitter Saturation Voltage (Note 1)		1.5		1.5	V	I_C = 2.5 A, I_B = 0.5 A

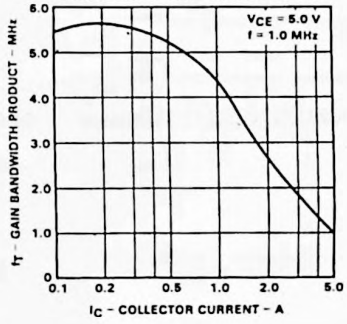
NOTE: 1. Pulse conditions: Length = 300 μs, Duty Cycle = 2%.

TYPICAL ELECTRICAL CHARACTERISTICS

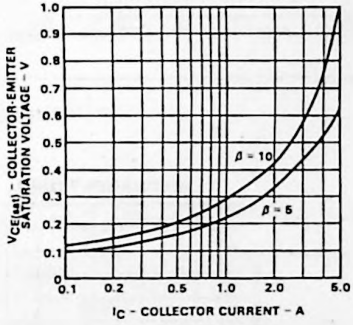
DC CURRENT GAIN



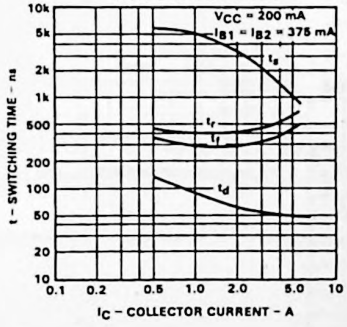
GAIN BANDWIDTH PRODUCT



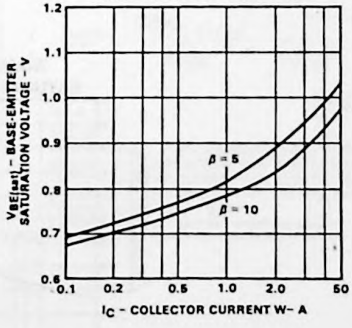
COLLECTOR-EMITTER SATURATION VOLTAGE



SWITCHING TIMES



BASE-EMITTER SATURATION VOLTAGE



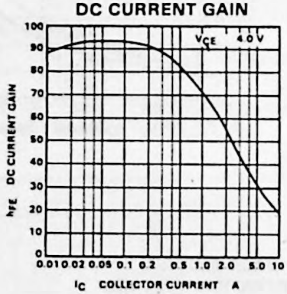
ELECTRICAL CHARACTERISTICS (25°C Case Temperature unless otherwise noted)

SYMBOL	CHARACTERISTIC	FT2955 MIN	FT2955 MAX	UNIT	TEST CONDITIONS
OFF CHARACTERISTICS					
$V_{CEO(sus)}$	Collector-Emitter Sustaining Voltage (Note 1)	−60		V	I_C = 200 mA, I_B = 0
$V_{CER(sus)}$	Collector-Emitter Sustaining Voltage (Note 1)	−70		V	I_C = 200 mA, R_{BE} = 100 Ω
I_{CEO}	Collector Cutoff Current		0.7	mA	V_{CE} = −30 V, I_B = 0
I_{CEX}	Collector Cutoff Current		5.0 30	mA mA	V_{CE} = −100 V, V_{BE} = 1.5 V V_{CE} = −100 V, V_{BE} = 1.5 V, T_C = 125°C
I_{EBO}	Emitter Cutoff Current		5.0	mA	V_{EB} = −7.0 V, I_C = 0
ON CHARACTERISTICS					
h_{FE}	DC Current Gain (Note 1)	5.0 20	 70		I_C = 10 A, V_{CE} = −4.0 V I_C = 4.0 A, V_{CE} = −4.0 V
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage (Note 1)		−1.1 −8.0	V V	I_C = 4.0 A, I_B = 400 mA I_C = 10 A, I_B = 3.3 A
$V_{BE(on)}$	Base-Emitter "On" Voltage (Note 1)		−1.8	V	I_C = 4.0 A, V_{CE} = −4.0 V
DYNAMIC CHARACTERISTICS					
f_T	Current-Gain-Bandwidth Product	2.0		MHz	I_C = 500 mA, V_{CE} = −10 V, f = 500 kHz
$\lvert h_{fe} \rvert$	Small Signal Current Gain	15	120		I_C = 1.0 A, V_{CE} = −4.0 V, f = 1 kHz

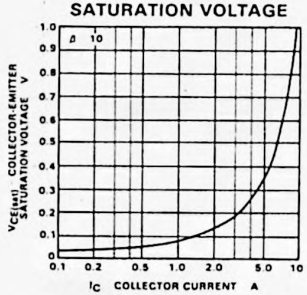
NOTE: 1. Pulse conditions: Length = 300 μs, Duty Cycle = 2%.

TYPICAL ELECTRICAL CHARACTERISTICS

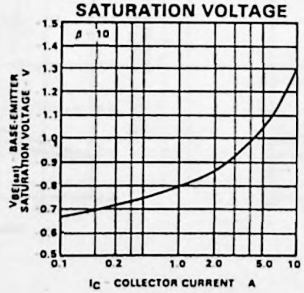
DC CURRENT GAIN



COLLECTOR-EMITTER SATURATION VOLTAGE



BASE-EMITTER SATURATION VOLTAGE



POWER TRANSISTOR

PNP SILICON

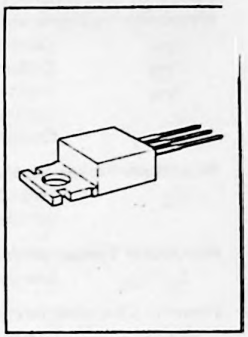
FT2955

DESIGNED FOR GENERAL PURPOSE SWITCHING AND AMPLIFIER APPLICATIONS

- 70 W DISSIPATION AT 25°C CASE
- 10 A MAXIMUM CONTINUOUS COLLECTOR CURRENT
- 70 MAXIMUM h_{FE} AT 4 Adc
- 1.1 Vdc MAXIMUM $V_{CE(sat)}$ AT 4 Adc

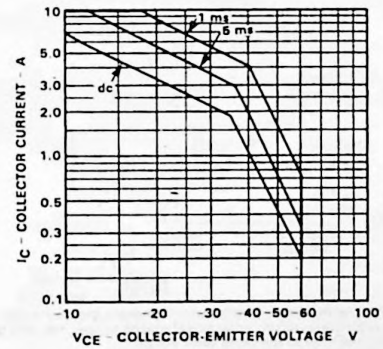
ABSOLUTE MAXIMUM RATINGS (Note 1)

Maximum Voltages and Currents		
V_{CEO}	Collector to Emitter Voltage	−60 V
V_{CBO}	Collector to Base Voltage	−100 V
V_{EBO}	Emitter to Base Voltage	−7.0 V
I_C	Continuous Collector Current	10 A
I_C	Peak Collector Current	15 A
I_B	Continuous Base Current	7.0 A
Maximum Power Dissipation		
P_D	Total Dissipation @ 25°C Case Temperature	70 W
	Derate Linearly from 25°C	0.56 W/°C
Maximum Temperatures		
T_J, T_{stg}	Storage and Operation Junction Temperatures	−65°C to +150°C
Thermal Characteristics		
$R_{\theta JC}$	Thermal Resistance, Junction to Case	1.79°C/W

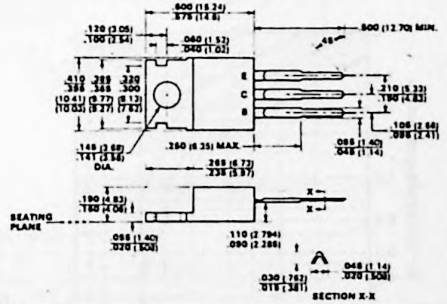


6

SAFE OPERATING AREA



JEDEC (TO-220) Outline**



NOTES:
All dimensions in inches (bold) and millimeters (parentheses)
Package is silicone plastic with nickel-plated copper tab and pins
*Mechanically interchangeable with TO-66
Center pin is electrical contact with the mounting tab
Package weight is 2.1 grams
**Available in various pin configurations

POWER TRANSISTOR

NPN SILICON

FT3055

DESIGNED FOR GENERAL PURPOSE AMPLIFIER AND SWITCHING APPLICATIONS

- 70 W DISSIPATION AT 25°C CASE
- 10 A MAXIMUM CONTINUOUS COLLECTOR CURRENT
- DC CURRENT GAIN SPECIFIED TO 10 A
- HIGH EFFICIENCY COMPACT PACKAGE

ABSOLUTE MAXIMUM RATINGS

Maximum Voltages and Currents

V_{CE}	Collector to Emitter Voltage	60 V
V_{CB}	Collector to Base Voltage	100 V
V_{EB}	Emitter to Base Voltage	7.0 V
I_C	Continuous Collector Current	10 A
I_B	Continuous Base Current	7.0 A

Maximum Power Dissipation

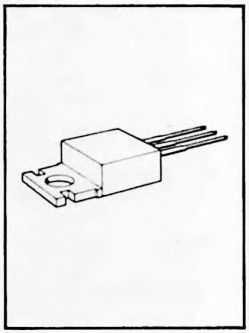
P_D	Total Dissipation @ 25°C Case Temperature	70 W
	Derate Linearly from 25°C	0.56 W/°C

Maximum Temperatures

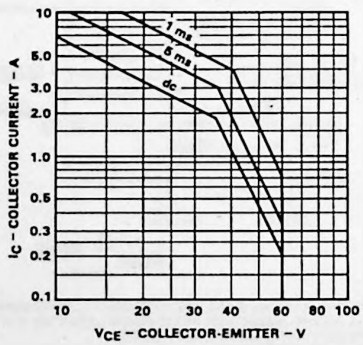
T_J, T_{stg}	Storage and Operating Junction Temperatures	−65°C to +150°C

Thermal Characteristics

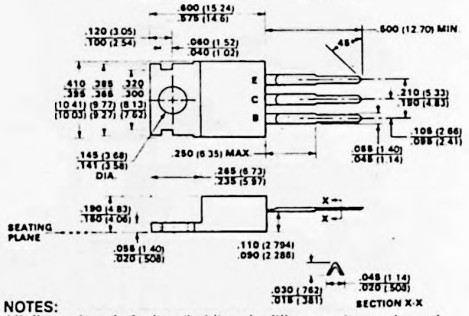
$R_{\theta JC}$	Thermal Resistance, Junction to Case	1.78°C/W



SAFE OPERATING AREA



JEDEC (TO-220) Outline**



NOTES:
All dimensions in inches (bold) and millimeters (parentheses)
Package is silicone plastic with nickel-plated copper tab and pins
*Mechanically interchangeable with TO-66
Center pin is electrical contact with the mounting tab
Package weight is 2.1 grams
**Available in various pin configurations

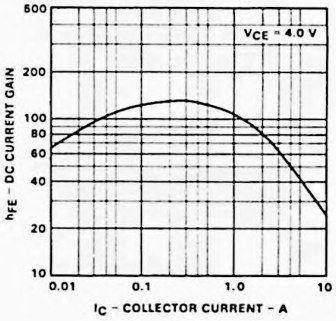
ELECTRICAL CHARACTERISTICS (25°C Case Temperature unless otherwise noted)

SYMBOL	CHARACTERISTICS	MIN	MAX	UNITS	TEST CONDITIONS
OFF CHARACTERISTICS					
I_{CEX}	Collector Cutoff Current		5.0 30	mA	V_{CE} = 100 V, V_{BE} = −1.5 V V_{CE} = 100 V, V_{BE} = −1.5 V, T_C = 150°C
I_{CBO}	Collector Cutoff Current		700	μA	V_{CB} = 70 V, I_E = 0
I_{EBO}	Emitter Cutoff Current		5.0	mA	V_{EB} = 7.0 V, I_C = 0
ON CHARACTERISTICS					
h_{FE}	DC Current Gain (Note 1)	20 5.0	70		I_C = 4.0 A, V_{CE} = 4.0 V I_C = 10 A, V_{CE} = 4.0 V
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage (Note 1)		1.1 8.0	V	I_C = 4.0 A, I_B = 0.4 A I_C = 10 A, I_B = 3.3 A
$V_{BE(on)}$	Base-Emitter "On" Voltage (Note 1)		1.8	V	I_C = 4.0 A, V_{CE} = 4.0 V
DYNAMIC CHARACTERISTICS					
f_T	Current-Gain-Bandwidth Product	10		MHz	I_C = 1.0 A, V_{CE} = 4.0 V

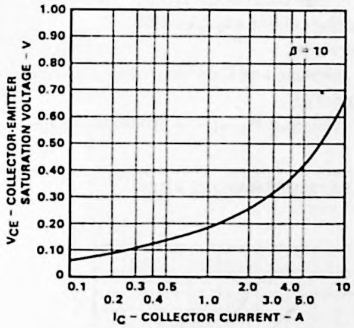
NOTE: 1. Pulse conditions: Length = 300 μs, Duty Cycle = 2%.

TYPICAL ELECTRICAL CHARACTERISTICS

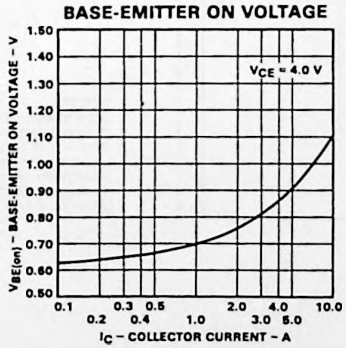
DC CURRENT GAIN



COLLECTOR-EMITTER SATURATION VOLTAGE



BASE-EMITTER ON VOLTAGE



POWER TRANSISTOR

NPN SILICON

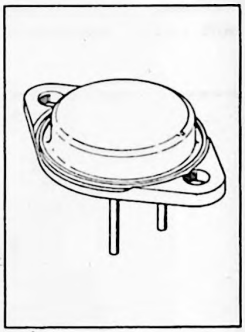
MJ802

HIGH POWER NPN TRANSISTOR FOR USE AS AN OUTPUT DEVICE IN COMPLEMENTARY AUDIO AMPLIFIERS

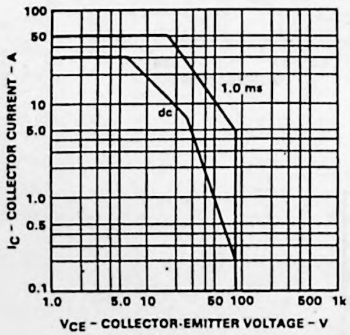
- 200 W DISSIPATION AT 25°C CASE
- 30 A MAXIMUM CONTINUOUS COLLECTOR CURRENT
- COMPLEMENT TO MJ4502

ABSOLUTE MAXIMUM RATINGS (Note 1)

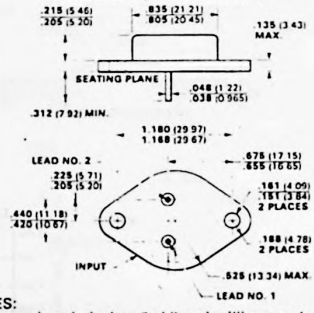
		MJ802
Maximum Voltages and Currents		
V_{CEO}	Collector to Emitter Voltage	90 V
V_{CBO}	Collector to Base Voltage	100 V
V_{EBO}	Emitter to Base Voltage	4.0 V
I_C	Continuous Collector Current	30 A
I_B	Continuous Base Current	7.5 A
Maximum Power Dissipation		
P_D	Total Dissipation @ 25°C Case Temperature	200 W
	Derate linearly from 25°C	1.14 W/°C
Maximum Temperatures		
T_J, T_{stg}	Storage and Operation Junction Temperatures	-65°C to +200°C
Thermal Characteristics		
$R_{\theta JC}$	Thermal Resistance, Junction to Case	0.875°C/W



SAFE OPERATING AREA



JEDEC (TO-3) Outline



NOTES:
All dimensions in inches (bold) and millimeters (parentheses)
Pins are gold-plated or solder-dipped alloy 52
Pins 1 and 2 electrically isolated from case
Case is third electrical connection
Aluminum package with copper slug, pins are soldered in
Package weight is 7.4 grams
Aluminum cap

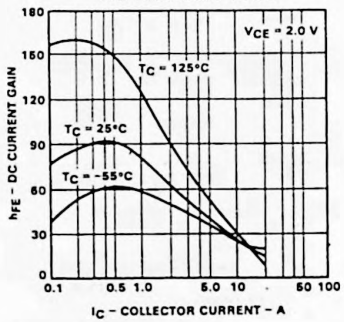
ELECTRICAL CHARACTERISTICS (25°C Case Temperature unless otherwise noted)

SYMBOL	CHARACTERISTIC	MJ802 MIN	MJ802 MAX	UNIT	TEST CONDITIONS
OFF CHARACTERISTICS					
$V_{CEO(sus)}$	Collector-Emitter Sustaining Voltage (Note 1)	90		V	I_C = 200 mA, I_B ≙ 0
$V_{CER(sus)}$	Collector-Emitter Sustaining Voltage (Note 1)	100		V	I_C = 200 mA, R_{BE} = 100 Ω
I_{CBO}	Collector Cutoff Current		1.0 5.0	mA mA	V_{CB} = 100 V, I_E = 0 V_{CB} = 100 V, I_E = 0, T_C = 150°C
I_{EBO}	Emitter Cutoff Current		1.0	mA	V_{EB} = 4.0 V, I_C = 0
ON CHARACTERISTICS					
h_{FE}	DC Current Gain (Note 1)	25	100		I_C = 7.5 A, V_{CE} = 2.0 V
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage (Note 1)		0.8	V	I_C = 7.5 A, I_B = 0.75 A
$V_{BE(sat)}$	Base-Emitter Saturation Voltage (Note 1)		1.3	V	I_C = 7.5 A, I_B = 0.75 A
$V_{BE(on)}$	Base-Emitter "On" Voltage (Note 1)		1.3	V	I_C = 7.5 A, V_{CE} = 2.0 V
DYNAMIC CHARACTERISTICS					
f_T	Current-Gain-Bandwidth Product	2.0		MHz	I_C = 1.0 A, V_{CE} = 10 V, f = 1.0 MHz

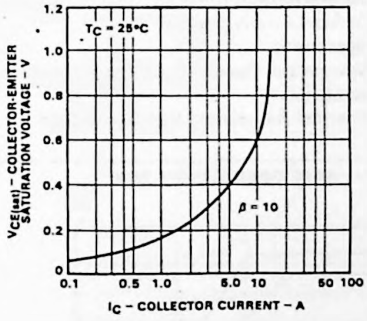
NOTE: 1. Pulse conditions: Length = 300 μs, Duty Cycle = 2%.

TYPICAL ELECTRICAL CHARACTERISTICS

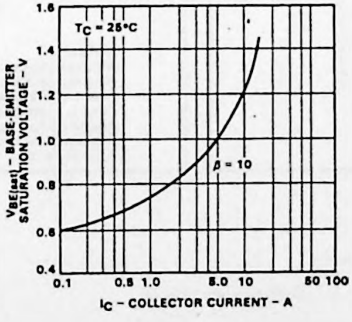
DC CURRENT GAIN



COLLECTOR-EMITTER SATURATION VOLTAGE



BASE-EMITTER SATURATION VOLTAGE



POWER TRANSISTOR

PNP SILICON

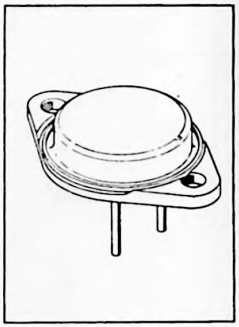
MJ4502

HIGH POWER PNP TRANSISTOR FOR USE AS AN OUTPUT DEVICE IN COMPLEMENTARY AUDIO AMPLIFIERS

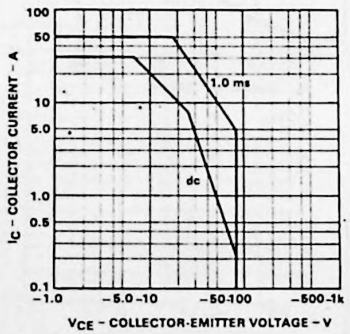
- 200 W DISSIPATION AT 25°C CASE
- 30 A MAXIMUM CONTINUOUS COLLECTOR CURRENT
- COMPLEMENT TO MJ802

ABSOLUTE MAXIMUM RATINGS (Note 1)

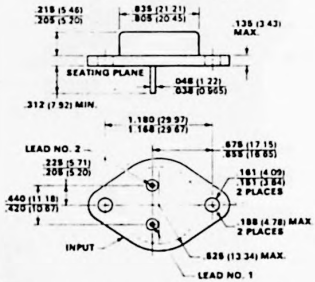
Maximum Voltages and Currents		
V_{CEO}	Collector to Emitter Voltage	−90 V
V_{CBO}	Collector to Base Voltage	−100 V
V_{EBO}	Emitter to Base Voltage	−4.0 V
I_C	Continuous Collector Current	30 A
I_B	Continuous Base Current	7.5 A
Maximum Power Dissipation		
P_D	Total Dissipation @ 25°C Case Temperature	200 W
	Derate Linearly from 25°C	1.14 W/°C
Maximum Temperatures		
T_J, T_{stg}	Storage and Operation Junction Temperatures	−65°C to +200°C
Thermal Characteristics		
$R_{\theta JC}$	Thermal Resistance, Junction to Case	0.875°C/W



SAFE OPERATING AREA



JEDEC (TO-3) Outline



NOTES:
All dimensions in inches (bold) and millimeters (parentheses)
Pins are gold-plated or solder-dipped alloy 52
Pins 1 and 2 electrically isolated from case
Case is third electrical connection
Aluminum package with copper slug, pins are soldered in
Package weight is 7.4 grams
Aluminum cap

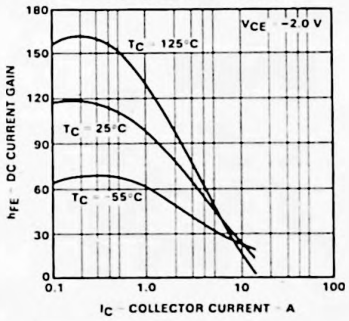
ELECTRICAL CHARACTERISTICS (25°C Case Temperature unless otherwise noted)

SYMBOL	CHARACTERISTIC	MJ4502 MIN	MJ4502 MAX	UNIT	TEST CONDITIONS
OFF CHARACTERISTICS					
$V_{CEO(sus)}$	Collector-Emitter Sustaining Voltage (Note 1)	−90		V	I_C = 200 mA, I_B = 0
$V_{CER(sus)}$	Collector-Emitter Sustaining Voltage (Note 1)	−100		V	I_C = 200 mA, R_{BE} = 100 Ω
I_{CBO}	Collector Cutoff Current		1.0 5.0	mA mA	V_{CB} = −100 V, I_E = 0 V_{CB} = −100 V, I_E = 0, T_C = 150°C
I_{EBO}	Emitter Cutoff Current		1.0	mA	V_{EB} = −4.0 V, I_C = 0
ON CHARACTERISTICS					
h_{FE}	DC Current Gain (Note 1)	25	100		I_C = 7.5 A, V_{CE} = −2.0 V
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage (Note 1)		−0.8	V	I_C = 7.5 A, I_B = 0.75 A
$V_{BE(sat)}$	Base-Emitter Saturation Voltage (Note 1)		−1.3	V	I_C = 7.5 A, I_B = 0.75 A
$V_{BE(on)}$	Base-Emitter "On" Voltage (Note 1)		−1.3	V	I_C = 7.5 A, V_{CE} = −2.0 V
DYNAMIC CHARACTERISTICS					
f_T	Current-Gain-Bandwidth Product	2.0		MHz	I_C = 1.0 A, V_{CE} = −10 V, f = 1.0 MHz

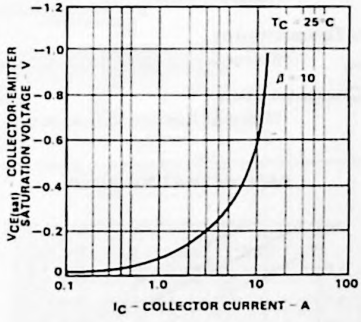
NOTE: 1. Pulse conditions: Length = 300 μs, Duty Cycle = 2%.

TYPICAL ELECTRICAL CHARACTERISTICS

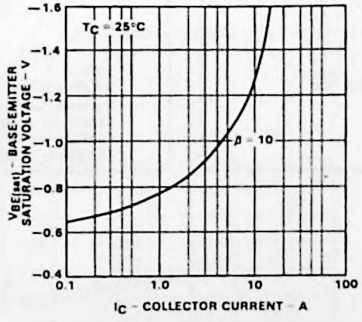
DC CURRENT GAIN



COLLECTOR-EMITTER SATURATION VOLTAGE



BASE-EMITTER SATURATION VOLTAGE



POWER TRANSISTOR

NPN SILICON

MJE3055F

DESIGNED FOR GENERAL PURPOSE AMPLIFIER AND SWITCHING APPLICATIONS

- 70 W DISSIPATION AT 25°C CASE
- 10 A MAXIMUM CONTINUOUS COLLECTOR CURRENT
- PIN OUT COMPATIBLE WITH MJE3055
- DC CURRENT GAIN SPECIFIED TO 10 A
- 2 MHz MINIMUM f_T AT 500 mA
- HIGH EFFICIENCY COMPACT PACKAGE

ABSOLUTE MAXIMUM RATINGS

Maximum Voltages and Currents

V_{CE}	Collector to Emitter Voltage	60 V
V_{CB}	Collector to Base Voltage	70 V
V_{EB}	Emitter to Base Voltage	5 V
I_C	Continuous Collector Current	10 A
I_B	Continuous Base Current	6 A

Maximum Power Dissipation

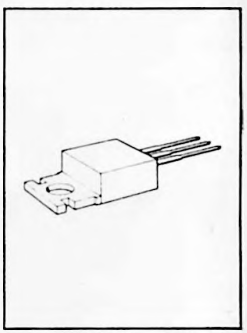
P_D	Total Dissipation @ 25°C Case Temperature	70 W
	Derate Linearly from 25°C	0.56 W/°C

Maximum Temperatures

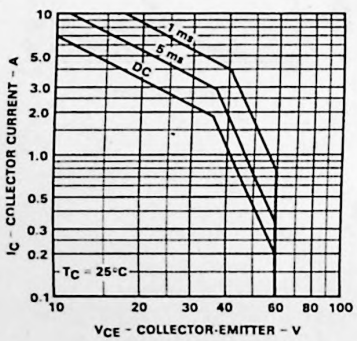
T_J, T_{stg}	Storage and Operating Junction Temperatures	−55°C to +150°C

Thermal Characteristics

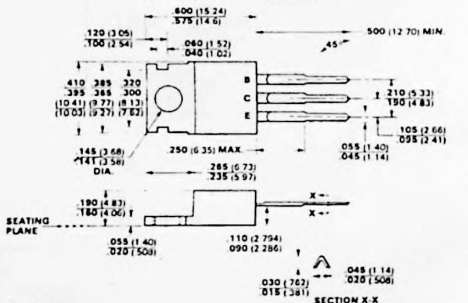
$R_{\theta JC}$	Thermal Resistance, Junction to Case	1.78 °C/W



SAFE OPERATING AREA



JEDEC (TO-220) Outline*



NOTES:
All dimensions in inches (bold) and millimeters (parentheses) .
Package is silicone plastic with nickel-plated copper tab and pins
Center pin is electrical contact with the mounting tab
Package weight is 2.1 grams
*Available in various pin configurations

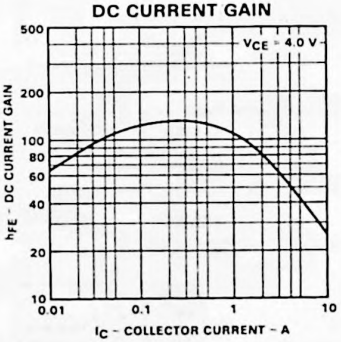
ELECTRICAL CHARACTERISTICS (25°C Case Temperature unless otherwise noted)

SYMBOL	PARAMETER	MIN	MAX	UNITS	TEST CONDITIONS
OFF CHARACTERISTICS					
$V_{CEO(sus)}$	Collector-Emitter Sustaining Voltage (Note 1)	60		V	I_C = 200 mA, I_B = 0
I_{CEO}	Collector Cutoff Current		0.7	mA	V_{CE} = 30 V, I_B = 0
I_{CEX}	Collector Cutoff Current		1.0 5.0	mA	V_{CE} = 70 V, V_{BE} = −1.5 V V_{CE} = 70 V, V_{BE} = −1.5 V, T_C = 150°C
I_{CBO}	Collector Cutoff Current		1.0 10	mA	V_{CB} = 70 V, I_E = 0 V_{CB} = 70 V, I_E = 0, T_C = 150°C
I_{EBO}	Emitter Cutoff Current		5.0	mA	V_{EB} = 5.0 V, I_C = 0
ON CHARACTERISTICS					
h_{FE}	DC Current Gain (Note 1)	20 5.0	70		I_C = 4.0 A, V_{CE} = 4.0 V I_C = 10 A, V_{CE} = 4.0 V
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage (Note 1)		1.1 8.0	V	I_C = 4.0 A, I_B = 0.4 A I_C = 10 A, I_B = 3.3 A
$V_{BE(on)}$	Base-Emitter "On" Voltage (Note 1)		1.8	V	I_C = 4.0 A, V_{CE} = 4.0 V
DYNAMIC CHARACTERISTICS					
f_T	Current-Gain-Bandwidth Product	2.0		MHz	I_C = 500 mA, V_{CE} = 10 V, f = 500 kHz

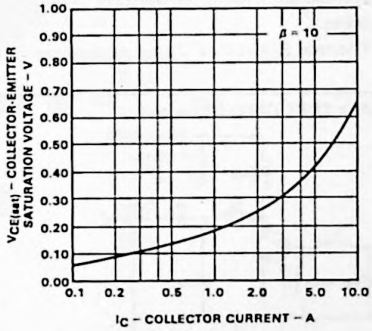
NOTE: 1. Pulse conditions: Length = 300 μs, Duty Cycle = 2%.

TYPICAL ELECTRICAL CHARACTERISTICS

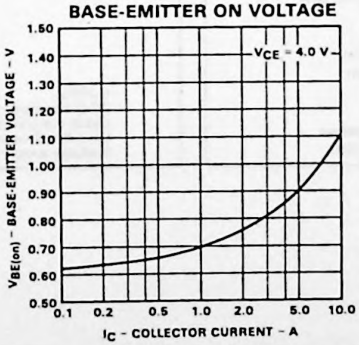
DC CURRENT GAIN



COLLECTOR-EMITTER SATURATION VOLTAGE



BASE-EMITTER ON VOLTAGE



POWER TRANSISTOR

NPN SILICON

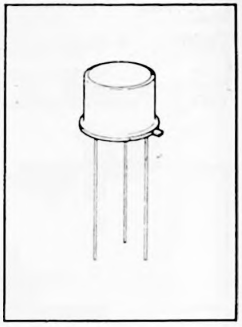
MRF8004

DESIGNED PRIMARILY FOR USE IN LARGE SIGNAL OUTPUT AMPLIFIER STAGES

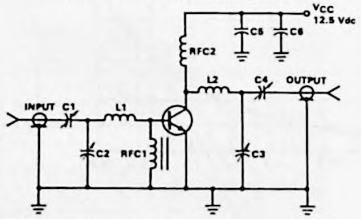
- INTENDED FOR USE IN CITIZEN BAND COMMUNICATION EQUIPMENT OPERATING TO 30 MHz
- HIGH BREAKDOWN VOLTAGES ALLOW A HIGH PERCENTAGE OF UP-MODULATION IN AM CIRCUITS
- SPECIFIED 12.5 V, 27 MHz CHARACTERISTICS
  - 3.5 W - POWER OUTPUT
  - 10 dB - POWER GAIN
  - 70% TYPICAL - EFFICIENCY

ABSOLUTE MAXIMUM RATINGS (Note 1)

		MRF8004
Maximum Voltages and Currents		
V_{CEO}	Collector to Emitter Voltage	30 V
V_{CBO}	Collector to Base Voltage	60 V
V_{EBO}	Emitter to Base Voltage	3.0 V
I_C	Continuous Collector Current	1.0 A
Maximum Power Dissipation		
P_D	Total Dissipation @ 25°C Case Temperature (Note 1)	5.0 W
	Derate Linearly from 25°C	28.6 mW/°C
Maximum Temperatures		
T_J, T_{stg}	Storage and Operation Junction Temperatures	−65°C to +200°C
Thermal Characteristics		
$R_{\theta JC}$	Thermal Resistance, Junction to Case	35°C/W

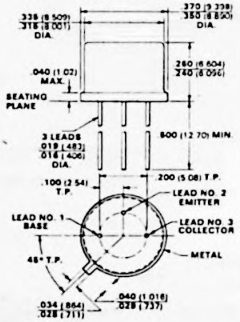


27 MHz TEST CIRCUIT (Note 2)



RFC2	26 Turns #22 Enameled Wire (2 Layers – 13 Turns Each Layer) 1/4" Inner Diameter
L1	0.22 μH Molded Choke
L2	0.68 μH Molded Choke
C1, C2	9.0–180 pF ARCO 463 or Equivalent
C3, C4	5.0–80 pF ARCO 462 or Equivalent
C5	0.02 μF Ceramic Disc
C6	0.1 μF Ceramic Disc
RFC1	4 Turns #30 Enameled Wire Wound on Ferroxcube Bead Type 56-590-65/3B

JEDEC (TO-39) outline



NOTES:
All dimensions in inches (bold) and millimeters (parentheses)
Leads are gold-plated kovar
Lead No. 3 connected to case
Package weight is 0.76 gram

ELECTRICAL CHARACTERISTICS (25°C Case Temperature unless otherwise noted)

SYMBOL	CHARACTERISTIC	MRF8004 MIN	MRF8004 MAX	UNIT	TEST CONDITIONS
OFF CHARACTERISTICS					
$V_{CEO(sus)}$	Collector-Emitter Sustaining Voltage (Note 1)	30		V	I_C = 50 mA, I_B = 0
V_{CES}	Collector-Emitter Breakdown Voltage	60		V	I_C = 200 mA, V_{BE} = 0
V_{EBO}	Emitter-Base Breakdown Voltage	3.0		V	I_E = 1.0 mA, I_C = 0
I_{CBO}	Collector Cutoff Current		0.01	mA	V_{CB} = 50 V, I_E = 0
ON CHARACTERISTICS					
h_{FE}	DC Current Gain (Note 1)	10			I_C = 400 mA, V_{CE} = 2.0 V
DYNAMIC CHARACTERISTICS					
C_{ob}	Output Capacitance		70	pF	V_{CB} = 12.5 V, I_E = 0, f = 1.0 MHz
FUNCTIONAL TESTS					
G_{PE}	Common-Emitter Amplifier Power Gain	10		dB	f = 27 MHz, V_{CC} = 12.5 V, P_{out} = 3.5 W
η	Collector Efficiency (Note 3)	62.5		%	f = 27 MHz, V_{CC} = 12.5 V, P_{out} = 3.5 W
R_{in}	Parallel Equivalent Input Resistance		21 TYP	Ω	P_{out} = 3.5 W, V_{CC} = 12.5 V, f = 27 MHz
C_{in}	Parallel Equivalent Input Capacitance		900 TYP	pF	P_{out} = 3.5 W, V_{CC} = 12.5 V, f = 27 MHz
C_{out}	Parallel Equivalent Output Capacitance		200 TYP	pF	P_{out} = 3.5 W, V_{CC} = 12.5 V, f = 27 MHz

NOTES:

1. Pulse conditions: Length = 300 μs, Duty Cycle = 2%.
2. Percentage up-modulation is measured in this test circuit (Figure 1) by setting the Carrier Power (P_C) to 3.5 watts with V_{CC} = 12.5 Vdc and noting the power input. Then the peak envelope power (PEP) is noted after doubling the original power input to simulate driver modulation (at a 25% duty cycle for thermal considerations) and raising the V_{CC} to 25 Vdc (to simulate the modulating voltage). Percentage up-modulation is then determined by the relation—

$$\text{Percentage Up-Modulation} = \left[\left(\frac{PEP}{P_C}\right)^{1/2} - 1\right] \cdot 100$$

3. $\eta = \dfrac{R_F\ P_{out}}{(V_{CC})\ (I_C)} \cdot 100$

POWER TRANSISTOR

NPN SILICON

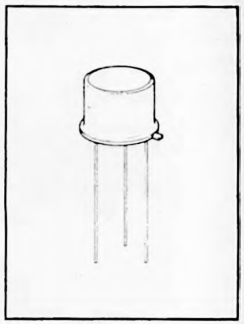
SE7055
SE7056

DESIGNED AS A HIGH VOLTAGE VIDEO OUTPUT

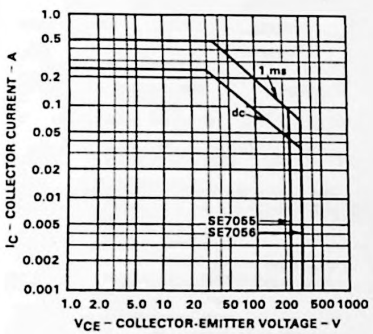
- 7.0 W DISSIPATION AT 25°C
- 500 mA MAXIMUM CONTINUOUS COLLECTOR CURRENT
- V_{CEO} 220 V MIN (SE7055), 300 V MIN (SE7056)

ABSOLUTE MAXIMUM RATINGS (Note 1)

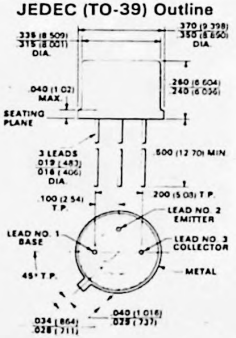
		SE7055	SE7056
Maximum Voltages and Currents			
V_{CEO}	Collector to Emitter Voltage	220 V	300 V
V_{CBO}	Collector to Base Voltage	220 V	300 V
V_{EBO}	Emitter to Base Voltage	7.0 V	7.0 V
I_C	Continuous Collector Current	500 mA	500 mA
Maximum Power Dissipation			
P_D	Total Dissipation @ 25°C Case Temperature		7.0 W
	Derate Linearly from 25°C		28.5 mW/°C
Maximum Temperatures			
T_J, T_{stg}	Storage and Operation Junction Temperatures		−65°C to +200°C
Thermal Characteristics			
$R_{\theta JC}$	Thermal Resistance, Junction to Case		25°C/W



SAFE OPERATING AREA



JEDEC (TO-39) Outline



NOTES:
All dimensions in inches (bold) and millimeters (parentheses)
Leads are gold-plated kovar
Lead No. 3 connected to case
Package weight is 0.76 gram

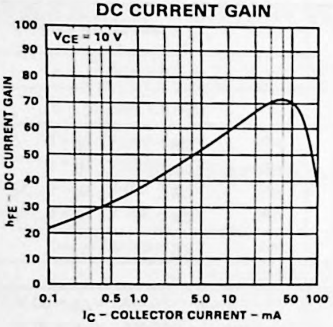
ELECTRICAL CHARACTERISTICS (25°C Case Temperature unless otherwise noted)

SYMBOL	CHARACTERISTIC	SE7055		SE7056		UNIT	TEST CONDITIONS
		MIN	MAX	MIN	MAX		
OFF CHARACTERISTICS							
$V_{CEO(sus)}$	Collector-Emitter Sustaining Voltage (Note 1)	220		300		V	I_C = 5.0 mA, I_B = 0
V_{CBO}	Collector-Base Breakdown Voltage	220		300		V	I_C = 0.1 mA, I_E = 0
V_{EBO}	Emitter-Base Breakdown Voltage	7.0		7.0		V	I_E = 0.1 mA, I_C = 0
I_{CBO}	Collector Cutoff Current		0.1			μA	V_{CB} = 150 V, I_E = 0
					0.1	μA	V_{CB} = 200 V, I_E = 0
			5.0			μA	V_{CB} = 150 V, I_E = 0, T_C = 125°C
					5.0	μA	V_{CB} = 200 V, I_E = 0, T_C = 125°C
I_{EBO}	Emitter Cutoff Current		0.1		0.1	mA	V_{EB} = 6.0 V, I_C = 0
ON CHARACTERISTICS							
h_{FE}	DC Current Gain (Note 1)	40		40			I_C = 30 mA, V_{CE} = 20 V
		40		40			I_C = 10 mA, V_{CE} = 20 V
		20		20			I_C = 1.0 mA, V_{CE} = 20 V
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage (Note 1)		1.0		1.0	V	I_C = 20 mA, I_B = 2.0 mA
$V_{BE(sat)}$	Base-Emitter Saturation Voltage (Note 1)		0.85		0.85	V	I_C = 20 mA, I_B = 2.0 mA
DYNAMIC CHARACTERISTICS							
C_{cb}	Collector-Base Capacitance		3.5		3.5	pF	V_{CB} = 20 V, I_E = 0, f = 1.0 MHz
C_{eb}	Emitter-Base Capacitance		70		70	pF	V_{EB} = 0.5 V, I_C = 0, f = 1.0 MHz
h_{fe}	High Frequency Current Gain	2.5					I_C = 15 mA, V_{CE} = 100 V, f = 20 MHz
h_{fe}	High Frequency Current Gain			2.5			I_C = 15 mA, V_{CE} = 150 V, f = 20 MHz
h_{fe}	High Frequency Current Gain	2.0					I_C = 3.0 mA, V_{CE} = 200 V, f = 20 MHz, R_L = 6.7 KΩ
		2.0					I_C = 30 mA, V_{CE} = 20 V, f = 20 MHz, R_L = 6.7 KΩ
				2.0			I_C = 3.0 mA, V_{CE} = 270 V, f = 20 MHz, R_L = 9.0 KΩ
				2.0			I_C = 30 mA, V_{CE} = 30 V, f = 20 MHz, R_L = 9.0 KΩ

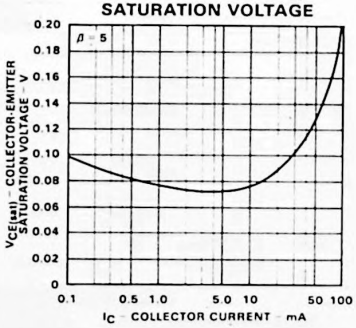
NOTE: 1. Pulse conditions: Length = 300 μs, Duty Cycle = 2%.

TYPICAL ELECTRICAL CHARACTERISTICS

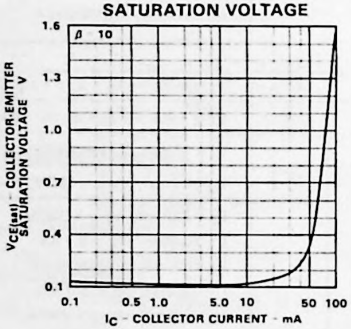
DC CURRENT GAIN



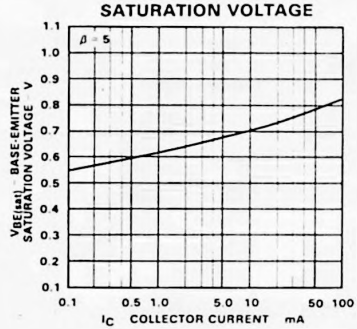
COLLECTOR-EMITTER SATURATION VOLTAGE



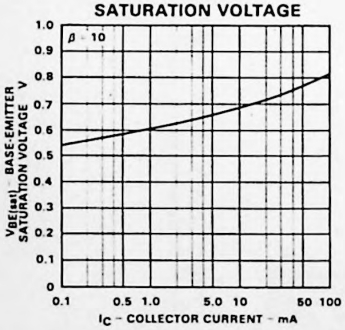
COLLECTOR-EMITTER SATURATION VOLTAGE



BASE-EMITTER SATURATION VOLTAGE



BASE-EMITTER SATURATION VOLTAGE

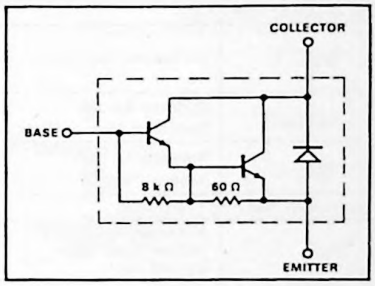


POWER DARLINGTON

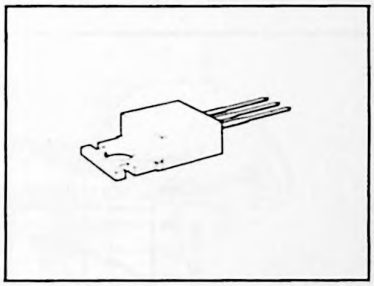
NPN SILICON

SE9300
SE9301
SE9302

DESIGNED FOR GENERAL PURPOSE AMPLIFIER AND LOW SPEED SWITCHING APPLICATIONS



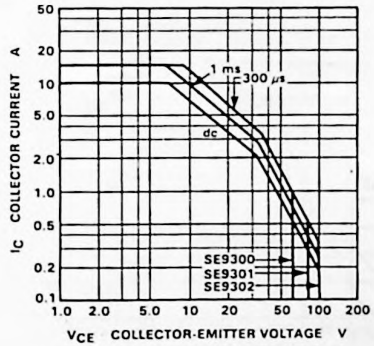
- 70 W DISSIPATION AT 25°C CASE
- 10 A MAXIMUM CONTINUOUS COLLECTOR CURRENT
- COMPLEMENT SE9400, SE9401, SE9402



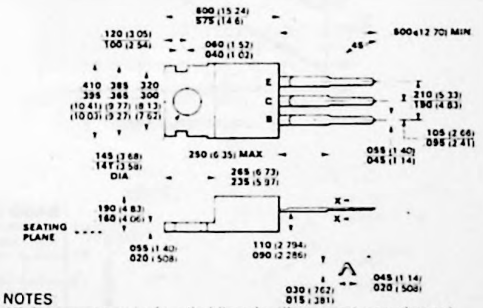
ABSOLUTE MAXIMUM RATINGS (Note 1)

		SE9300	SE9301	SE9302
Maximum Voltages and Currents				
V_{CEO}	Collector to Emitter Voltage	60 V	80 V	100 V
V_{CBO}	Collector to Base Voltage	60 V	80 V	100 V
V_{EBO}	Emitter to Base Voltage	5.0 V	5.0 V	5.0 V
I_C	Continuous Collector Current	10 A	10 A	10 A
Maximum Power Dissipation				
P_D	Total Dissipation @ 25°C Case Temperature			70 W
	Derate Linearly from 25°C			0.56 W/°C
Maximum Temperatures				
T_J, T_{stg}	Storage and Operation Junction Temperatures			−65°C to +150°C
Thermal Characteristics				
$R_{\theta JC}$	Thermal Resistance, Junction to Case			1.79°C/W

SAFE OPERATING AREA



JEDEC (TO-220) Outline**



NOTES
All dimensions in inches (bold) and millimeters (parentheses)
Package is silicone plastic with nickel-plated copper tab and pins
*Mechanically interchangeable with TO-66
Center pin is electrical contact with the mounting tab
Package weight is 2.1 grams
**Available in various pin configurations

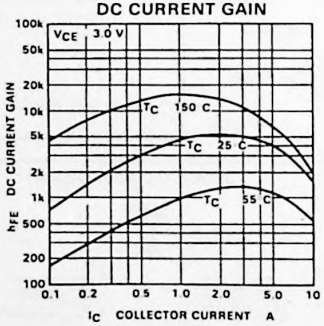
ELECTRICAL CHARACTERISTICS (25°C Case Temperature unless otherwise noted)

SYMBOL	CHARACTERISTIC	SE9300		SE9301		SE9302		UNITS	TEST CONDITIONS
		MIN	MAX	MIN	MAX	MIN	MAX		
OFF CHARACTERISTICS									
$V_{CEO(sus)}$	Collector-Emitter Sustaining Voltage (Note 1)	60		80		100		V	I_C = 100 mA, I_B = 0
I_{CEO}	Collector Cutoff Current		0.5		0.5		0.5	mA mA mA	V_{CE} = 30 V, I_B = 0 V_{CE} = 40 V, I_B = 0 V_{CE} = 50 V, I_B = 0
I_{CBO}	Collector Cutoff Current		0.2		0.2		0.2	mA mA mA	V_{CB} = 30 V, I_E = 0 V_{CB} = 40 V, I_E = 0 V_{CB} = 50 V, I_E = 0
I_{EBO}	Emitter Cutoff Current		4.0		4.0		4.0	mA	V_{EB} = 5.0 V, I_C = 0
ON CHARACTERISTICS									
h_{FE}	DC Current Gain (Note 1)	750 1000 100		750 1000 100		750 1000 100			I_C = 1.0 A, V_{CE} = 3.0 V I_C = 4.0 A, V_{CE} = 3.0 V I_C = 7.5 A, V_{CE} = 3.0 V
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage (Note 1)		2.0 2.5		2.0 2.5		2.0 2.5	V V	I_C = 4.0 A, I_B = 16 mA I_C = 7.5 A, I_B = 150 mA
$V_{BE(on)}$	Base-Emitter "On" Voltage (Note 1)		2.5 3.0		2.5 3.0		2.5 3.0	V V	I_C = 4.0 A, V_{CE} = 3.0 V I_C = 7.5 A, V_{CE} = 3.0 V
DYNAMIC CHARACTERISTICS									
$\|h_{fe}\|$	Magnitude of Common Emitter Small Signal Current Gain	1.0		1.0		1.0			I_C = 4.0 A, V_{CE} = 3.0 V, f = 1.0 MHz

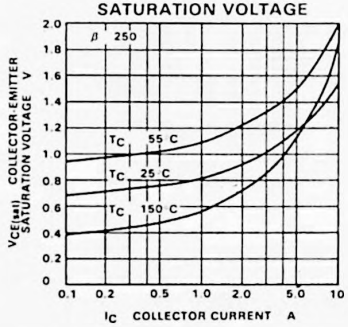
NOTE 1 Pulse conditions: Length = 300 μs, Duty Cycle = 2%.

TYPICAL ELECTRICAL CHARACTERISTICS

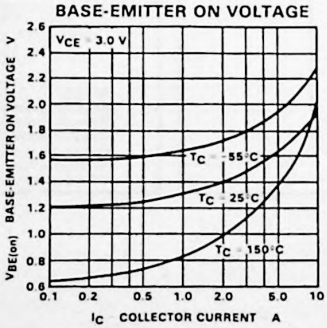
DC CURRENT GAIN



COLLECTOR-EMITTER SATURATION VOLTAGE



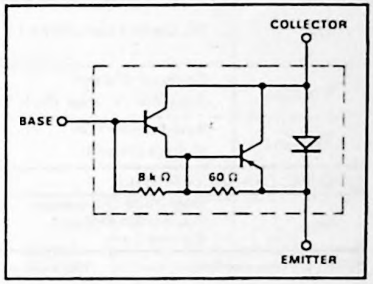
BASE-EMITTER ON VOLTAGE



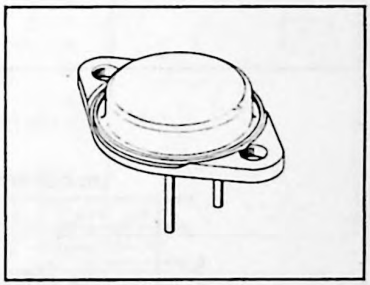
POWER DARLINGTON
NPN SILICON

SE9303
SE9304
SE9305

DESIGNED FOR GENERAL PURPOSE AMPLIFIER AND LOW SPEED SWITCHING APPLICATIONS



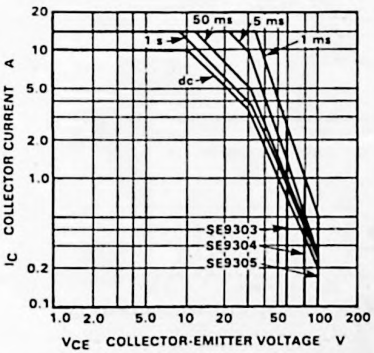
- 100 W DISSIPATION AT 25°C CASE
- 10 A MAXIMUM CONTINUOUS COLLECTOR CURRENT
- 1000 MINIMUM h_{FE} @ 4 A
- COMPLEMENT SE9403, SE9404, SE9405



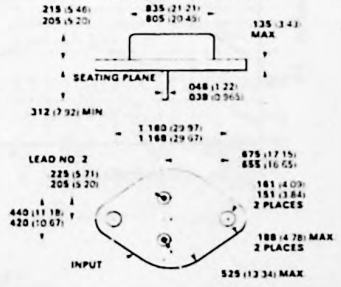
ABSOLUTE MAXIMUM RATINGS (Note 1)

		SE9303	SE9304	SE9305
Maximum Voltages and Currents				
V_{CEO}	Collector to Emitter Voltage	60 V	80 V	100 V
V_{CBO}	Collector to Base Voltage	60 V	80 V	100 V
V_{EBO}	Emitter to Base Voltage	5.0 V	5.0 V	5.0 V
I_C	Continuous Collector Current	10 A	10 A	10 A
Maximum Power Dissipation				
P_D	Total Dissipation @ 25°C Case Temperature			100 W
	Derate Linearly from 25°C			0.57 W/°C
Maximum Temperatures				
T_J, T_{stg}	Storage and Operation Junction Temperatures			−65°C to +200°C
Thermal Characteristics				
$R_{\theta JC}$	Thermal Resistance, Junction to Case			1.75°C/W

SAFE OPERATING AREA



JEDEC (TO-3) Outline



NOTES:
All dimensions in inches (bold) and millimeters (parentheses)
Pins are gold-plated or solder-dipped alloy 52
Pins 1 and 2 electrically isolated from case
Case is third electrical connection
Aluminum package with copper slug, pins are soldered in
Package weight is 7.4 grams
Aluminum cap

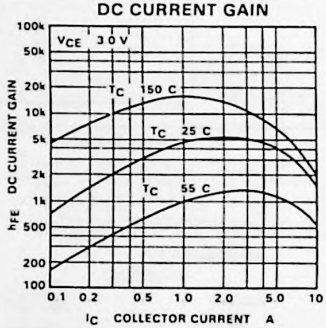
ELECTRICAL CHARACTERISTICS ($25^{\circ}C$ Case Temperature unless otherwise noted)

SYMBOL	CHARACTERISTIC	SE9303		SE9304		SE9305		UNITS	TEST CONDITIONS
		MIN	MAX	MIN	MAX	MIN	MAX		
OFF CHARACTERISTICS									
$V_{CEO(sus)}$	Collector-Emitter Sustaining Voltage (Note 1)	60		80		100		V	I_C = 100 mA, I_B = 0
I_{CEO}	Collector Cutoff Current		0.5		0.5			mA	V_{CE} = 30 V, I_B = 0
							0.5	mA	V_{CE} = 40 V, I_B = 0
								mA	V_{CE} = 50 V, I_B = 0
I_{CBO}	Collector Cutoff Current		0.2		0.2			mA	V_{CB} = 30 V, I_E = 0
							0.2	mA	V_{CB} = 40 V, I_E = 0
								mA	V_{CB} = 50 V, I_E = 0
I_{EBO}	Emitter Cutoff Current		4.0		4.0		4.0	mA	V_{EB} = 5.0 V, I_C = 0
ON CHARACTERISTICS									
h_{FE}	DC Current Gain (Note 1)	750		750		750			I_C = 1.0 A, V_{CE} = 3.0 V
		1000		1000		1000			I_C = 4.0 A, V_{CE} = 3.0 V
		100		100		100			I_C = 7.5 A, V_{CE} = 3.0 V
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage (Note 1)		2.0		2.0		2.0	V	I_C = 4.0 A, I_B = 16 mA
			2.5		2.5		2.5	V	I_C = 7.5 A, I_B = 150 mA
$V_{BE(on)}$	Base-Emitter "On" Voltage (Note 1)		2.5		2.5		2.5	V	I_C = 4.0 A, V_{CE} = 3.0 V
			3.0		3.0		3.0	V	I_C = 7.5 A, V_{CE} = 3.0 V
DYNAMIC CHARACTERISTICS									
$\lvert h_{fe} \rvert$	Magnitude of Common Emitter Small Signal Current Gain	1.0		1.0		1.0			I_C = 4.0 A, V_{CE} = 3.0 V, f = 1.0 MHz

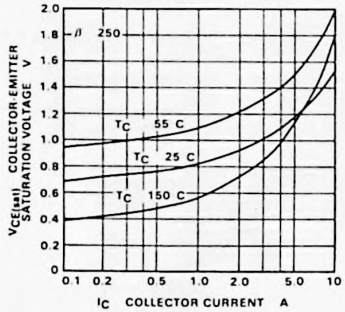
NOTE 1 Pulse conditions Length 300 μs, Duty Cycle 2%.

TYPICAL ELECTRICAL CHARACTERISTICS

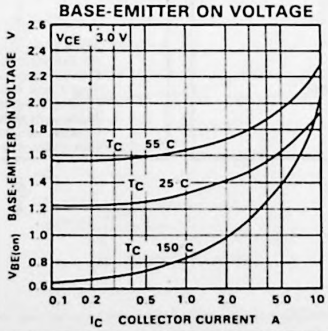
DC CURRENT GAIN



COLLECTOR-EMITTER SATURATION VOLTAGE



BASE-EMITTER ON VOLTAGE



POWER TRANSISTOR

NPN SILICON

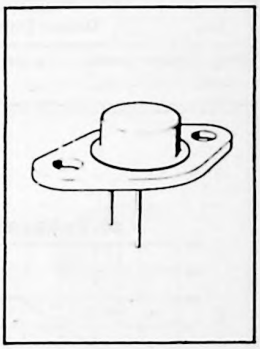
SE9331

GENERAL PURPOSE HIGH VOLTAGE POWER DEVICE

- 20 W DISSIPATION AT 25°C CASE
- 1.0 A MAXIMUM CONTINUOUS COLLECTOR CURRENT
- 300 V MINIMUM V_{CEO}

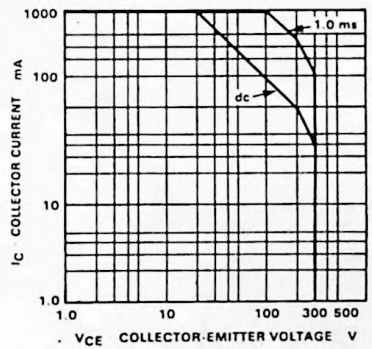
ABSOLUTE MAXIMUM RATINGS (Note 1)

Maximum Voltages and Currents		
V_{CEO}	Collector to Emitter Voltage	300 V
V_{CBO}	Collector to Base Voltage	300 V
V_{EBO}	Emitter to Base Voltage	6.0 V
I_C	Continuous Collector Current	1.0 A
I_B	Continuous Base Current	250 mA
Maximum Power Dissipation		
P_D	Total Dissipation @ 25°C Case Temperature	20 W
	Derate Linearly from 25°C	0.114 W/°C
Maximum Temperatures		
T_J, T_{stg}	Storage and Operation Junction Temperatures	−65°C to +175°C
Thermal Characteristics		
$R_{\theta JC}$	Thermal Resistance, Junction to Case	8.7 °C/W

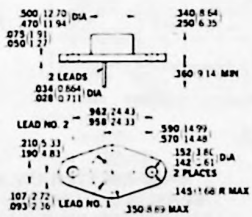


6

SAFE OPERATING AREA



JEDEC (TO-66) outline



NOTES:
All dimensions in inches (bold) and millimeters (parentheses)
Pins are gold-plated kovar
Pins 1 and 2 electrically isolated from case
Case is third electrical connection
Nickel-plated steel base and cap
Package weight is 6.5 grams

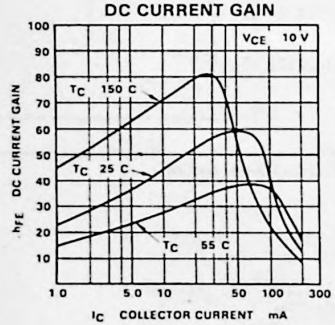
ELECTRICAL CHARACTERISTICS (25°C Case Temperature unless otherwise noted)

SYMBOL	CHARACTERISTIC	SE9331 MIN	SE9331 MAX	UNIT	TEST CONDITIONS
OFF CHARACTERISTICS					
$V_{CEO(sus)}$	Collector-Emitter Sustaining Voltage (Note 1)	300		V	I_C = 5.0 mA, I_B = 0
V_{EBO}	Emitter-Base Breakdown Voltage	6.0		V	I_E = 0.01 mA, I_C = 0
I_{CEO}	Collector Cutoff Current		0.1	mA	V_{CE} = 300 V, I_B = 0
I_{CBO}	Collector Cutoff Current		0.01 0.5	mA μA	V_{CB} = 300 V, I_E = 0 V_{CB} = 250 V, I_E = 0
ON CHARACTERISTICS					
h_{FE}	DC Current Gain (Note 1)	30 30	 250		I_C = 50 mA, V_{CE} = 10 V I_C = 100 mA, V_{CE} = 10 V
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage (Note 1)		2.5	V	I_C = 100 mA, I_B = 10 mA
$V_{BE(sat)}$	Base-Emitter Saturation Voltage (Note 1)		1.5	V	I_C = 100 mA, I_B = 10 mA
$V_{BE(on)}$	Base-Emitter "On" Voltage (Note 1)		1.5	V	I_C = 100 mA, V_{CE} = 10 V
DYNAMIC CHARACTERISTICS					
f_T	Current-Gain-Bandwidth Product	10		MHz	I_C = 50 mA, V_{CE} = 10 V, f = 10 MHz
C_{ob}	Output Capacitance		20	pF	V_{CB} = 100 V, I_E = 0, f = 1.0 MHz

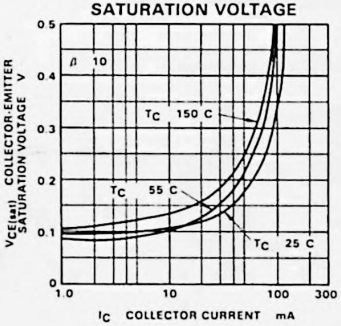
NOTE 1 Pulse conditions: Length = 300 μs, Duty Cycle = 2%.

TYPICAL ELECTRICAL CHARACTERISTICS

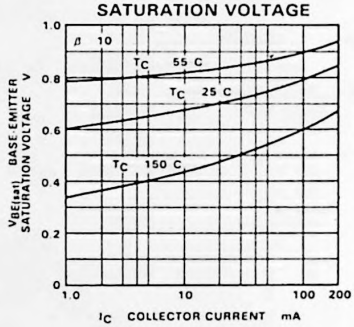
DC CURRENT GAIN



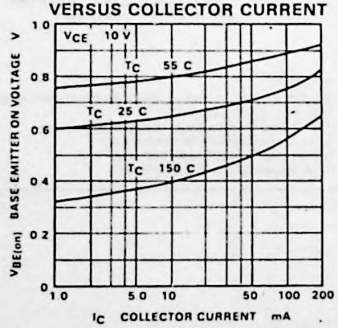
COLLECTOR-EMITTER SATURATION VOLTAGE



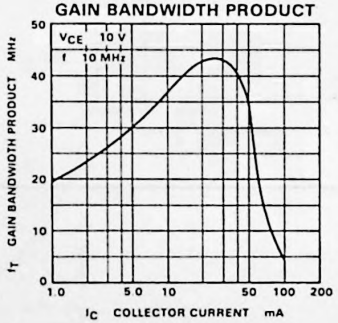
BASE-EMITTER SATURATION VOLTAGE



BASE-EMITTER ON VOLTAGE VERSUS COLLECTOR CURRENT



GAIN BANDWIDTH PRODUCT

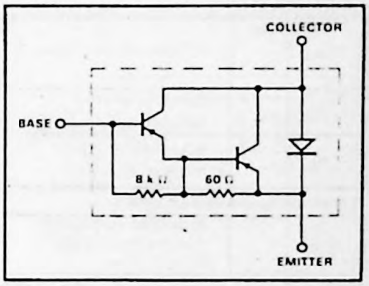


POWER DARLINGTON

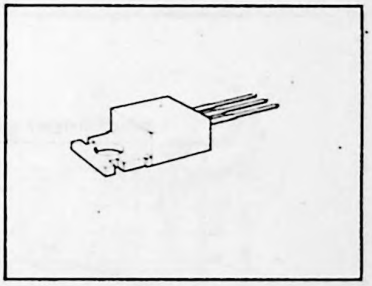
PNP SILICON

SE9400
SE9401
SE9402

DESIGNED FOR GENERAL PURPOSE AMPLIFIER AND LOW SPEED SWITCHING APPLICATIONS



- 70 W DISSIPATION AT 25°C CASE
- 10 A MAXIMUM CONTINUOUS COLLECTOR CURRENT
- 1000 MINIMUM h_{FE} @ 4 A
- COMPLEMENT SE9300, SE9301, SE9302

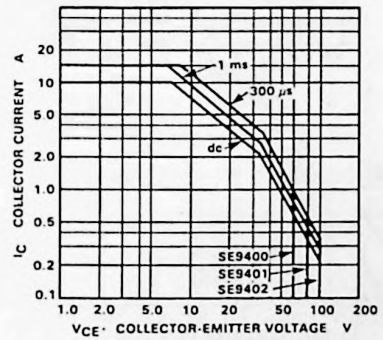


ABSOLUTE MAXIMUM RATINGS (Note 1)

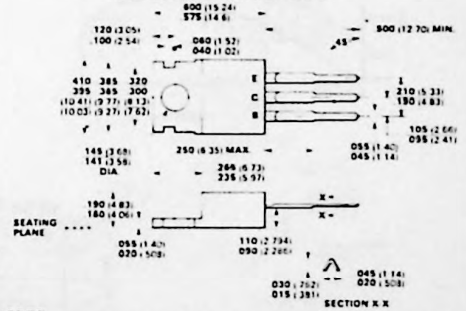
		SE9400	SE9401	SE9402
Maximum Voltages and Currents				
V_{CEO}	Collector to Emitter Voltage	−60 V	−80 V	−100 V
V_{CBO}	Collector to Base Voltage	−60 V	−80 V	−100 V
V_{EBO}	Emitter to Base Voltage	−5.0 V	−5.0 V	−5.0 V
I_C	Continuous Collector Current	10 A	10 A	10 A
Maximum Power Dissipation				
P_D	Total Dissipation @ 25°C Case Temperature			70 W
	Derate Linearly from 25°C			0.56 W/°C
Maximum Temperatures				
T_J, T_{stg}	Storage and Operation Junction Temperatures			−65°C to +150°C
Thermal Characteristics				
$R_{\theta JC}$	Thermal Resistance, Junction to Case			1.79°C/W

6

SAFE OPERATING AREA



JEDEC(TO-220) Outline**



NOTES
All dimensions in inches (bold) and millimeters (parentheses)
Package is silicone plastic with nickel-plated copper tab and pins
*Mechanically interchangeable with TO-66
Center pin is electrical contact with the mounting tab
Package weight is 2.1 grams
**Available in various pin configurations

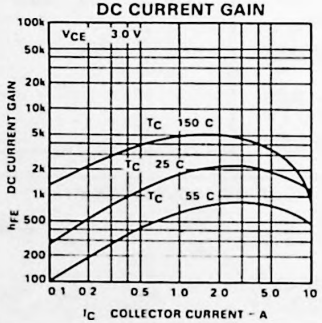
ELECTRICAL CHARACTERISTICS (25 C Case Temperature unless otherwise noted)

SYMBOL	CHARACTERISTIC	SE9400		SE9401		SE9402		UNITS	TEST CONDITIONS
		MIN	MAX	MIN	MAX	MIN	MAX		
OFF CHARACTERISTICS									
$V_{CEO(sus)}$	Collector Emitter Sustaining Voltage (Note 1)	-60		80		-100		V	I_C 100 mA, I_B 0
I_{CEO}	Collector Cutoff Current		0.5		0.5			mA	V_{CE} -30 V, I_B 0
								mA	V_{CE} -40 V, I_B 0
							0.5	mA	V_{CE} -50 V, I_B 0
I_{CBO}	Collector Cutoff Current		0.2		0.2			mA	V_{CB} -30 V, I_E 0
								mA	V_{CB} -40 V, I_E 0
							0.2	mA	V_{CB} -50 V, I_E 0
I_{EBO}	Emitter Cutoff Current		4.0		4.0		4.0	mA	V_{EB} -5.0 V, I_C 0
ON CHARACTERISTICS									
h_{FE}	DC Current Gain (Note 1)	750		750		750			I_C 1.0 A, V_{CE} -3.0 V
		1000		1000		1000			I_C 4.0 A, V_{CE} -3.0 V
		100		100		100			I_C 7.5 A, V_{CE} -3.0 V
$V_{CE(sat)}$	Collector Emitter Saturation Voltage (Note 1)		-2.0		-2.0		-2.0	V	I_C 4.0 A, I_B 16 mA
			-2.5		-2.5		-2.5	V	I_C 7.5 A, I_B 150 mA
$V_{BE(on)}$	Base Emitter "On" Voltage (Note 1)		-2.5		-2.5		-2.5	V	I_C 4.0 A, V_{CE} -3.0 V
			-3.0		-3.0		-3.0	V	I_C 7.5 A, V_{CE} -3.0 V
DYNAMIC CHARACTERISTICS									
$\|h_{fe}\|$	Magnitude of Common Emitter Small Signal Current Gain	1.0		1.0		1.0			I_C 4.0 A, V_{CE} -3.0 V, f 1.0 MHz

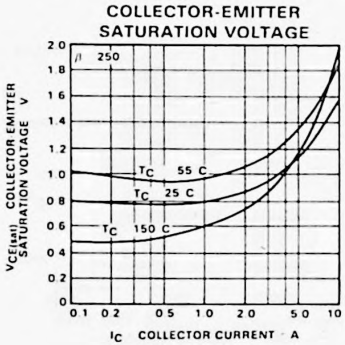
NOTE 1 Pulse conditions Length 300 μs, Duty Cycle 2%.

TYPICAL ELECTRICAL CHARACTERISTICS

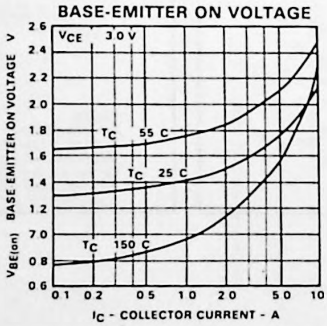
DC CURRENT GAIN



COLLECTOR-EMITTER SATURATION VOLTAGE



BASE-EMITTER ON VOLTAGE

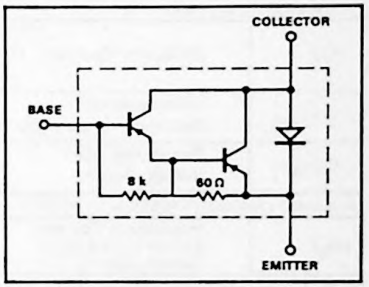


POWER DARLINGTON

PNP SILICON

SE9403
SE9404
SE9405

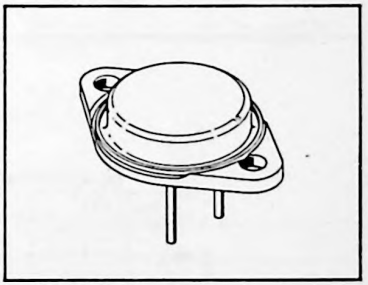
DESIGNED FOR GENERAL PURPOSE AMPLIFIER AND LOW SPEED SWITCHING APPLICATIONS



- 100 W DISSIPATION AT 25°C CASE
- 10 A MAXIMUM CONTINUOUS COLLECTOR CURRENT
- 1000 MINIMUM h_{FE} @ 4 A
- COMPLEMENT SE9303, SE9304, SE9305

ABSOLUTE MAXIMUM RATINGS (Note 1)

		SE9403	SE9404	SE9405
Maximum Voltages and Currents				
V_{CEO}	Collector to Emitter Voltage	-60 V	-80 V	-100 V
V_{CBO}	Collector to Base Voltage	-60 V	-80 V	-100 V
V_{EBO}	Emitter to Base Voltage	-5.0 V	-5.0 V	-5.0 V
I_C	Continuous Collector Current	10 A	10 A	10 A
Maximum Power Dissipation				
P_D	Total Dissipation @ 25°C Case Temperature			100 W
	Derate Linearly from 25°C			0.57 W/°C
Maximum Temperatures				
T_J, T_{stg}	Storage and Operation Junction Temperatures			-65°C to +200°C
Thermal Characteristics				
$R_{\theta JC}$	Thermal Resistance, Junction to Case			1.75°C/W



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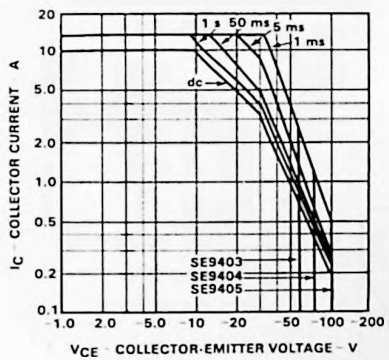
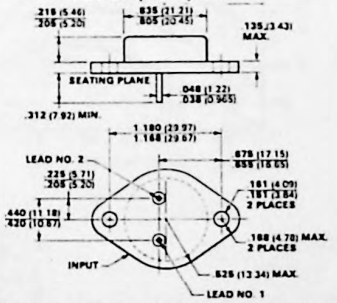
SAFE OPERATING AREA



JEDEC (TO-3) Outline



NOTES:
All dimensions in inches (bold) and millimeters (parentheses)
Pins are gold-plated or solder-dipped alloy 52
Pins 1 and 2 electrically isolated from case
Case is third electrical connection
Aluminum package with copper slug, pins are soldered in
Package weight is 7.4 grams
Aluminum cap

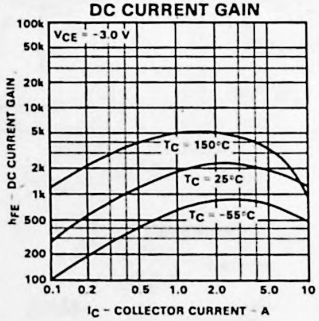
ELECTRICAL CHARACTERISTICS (25°C Case Temperature unless otherwise noted)

SYMBOL	CHARACTERISTIC	SE9403		SE9404		SE9405		UNITS	TEST CONDITIONS
		MIN	MAX	MIN	MAX	MIN	MAX		
OFF CHARACTERISTICS									
$V_{CEO(sus)}$	Collector-Emitter Sustaining Voltage (Note 1)	-60		-80		-100		V	I_C = 100 mA, I_B = 0
I_{CEO}	Collector Cutoff Current		0.5		0.5			mA	V_{CE} = -30 V, I_B = 0
								mA	V_{CE} = -40 V, I_B = 0
							0.5	mA	V_{CE} = -50 V, I_B = 0
I_{CBO}	Collector Cutoff Current		0.2		0.2			mA	V_{CB} = -30 V, I_E = 0
								mA	V_{CB} = -40 V, I_E = 0
							0.2	mA	V_{CB} = -50 V, I_E = 0
I_{EBO}	Emitter Cutoff Current		4.0		4.0		4.0	mA	V_{EB} = -5.0 V, I_C = 0
ON CHARACTERISTICS									
h_{FE}	DC Current Gain (Note 1)	750		750		750			I_C = 1.0 A, V_{CE} = -3.0 V
		1000		1000		1000			I_C = 4.0 A, V_{CE} = -3.0 V
		100		100		100			I_C = 7.5 A, V_{CE} = -3.0 V
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage (Note 1)		-2.0		-2.0		-2.0	V	I_C = 4.0 A, I_B = 16 mA
			-2.5		-2.5		-2.5	V	I_C = 7.5 A, I_B = 150 mA
$V_{BE(on)}$	Base-Emitter "On" Voltage (Note 1)		-2.5		-2.5		-2.5	V	I_C = 4.0 A, V_{CE} = -3.0 V
			-3.0		-3.0		-3.0	V	I_C = 7.5 A, V_{CE} = -3.0 V
DYNAMIC CHARACTERISTICS									
$\|h_{fe}\|$	Magnitude of Common Emitter Small Signal Current Gain	1.0		1.0		1.0			I_C = 4.0 A, V_{CE} = -3.0 V, f = 1.0 MHz

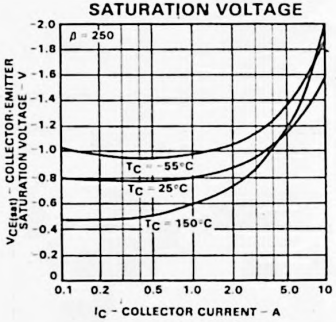
NOTE: 1. Pulse conditions: Length = 300 μs, Duty Cycle = 2%.

TYPICAL ELECTRICAL CHARACTERISTICS

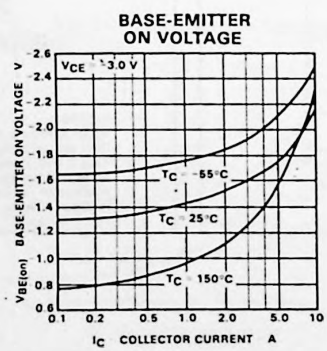
DC CURRENT GAIN



COLLECTOR-EMITTER SATURATION VOLTAGE



BASE-EMITTER ON VOLTAGE



POWER TRANSISTOR

NPN SILICON

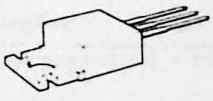
TIP29
TIP29A
TIP29B
TIP29C

DESIGNED FOR POWER AMPLIFIER AND HIGH SPEED SWITCHING APPLICATIONS

- 30 W DISSIPATION AT 25°C CASE
- 1 A MAXIMUM CONTINUOUS COLLECTOR CURRENT
- 15 TO 75 h_{FE} AT I_C 1 A
- COMPLEMENTS TIP30, TIP30A, TIP30B, TIP30C

ABSOLUTE MAXIMUM RATINGS (Note 1)

		TIP29	TIP29A	TIP29B	TIP29C
Maximum Voltages and Currents					
V_{CEO}	Collector to Emitter Voltage	40 V	60 V	80 V	100 V
V_{CBO}	Collector to Base Voltage	40 V	60 V	80 V	100 V
V_{EBO}	Emitter to Base Voltage	5.0 V	5.0 V	5.0 V	5.0 V
I_C	Continuous Collector Current	1.0 A	1.0 A	1.0 A	1.0 A
I_C	Peak Collector Current	3.0 A	3.0 A	3.0 A	3.0 A
I_B	Continuous Base Current	0.4 A	0.4 A	0.4 A	0.4 A
Maximum Power Dissipation					
P_D	Total Dissipation @ 25°C Case Temperature				30 W
	Derate Linearly from 25°C				0.24 W/°C
Maximum Temperatures					
T_J, T_{stg}	Storage and Operation Junction Temperatures				−65°C to +150°C
Thermal Characteristics					
$R_{\theta JC}$	Thermal Resistance, Junction to Case				4.16°C/W



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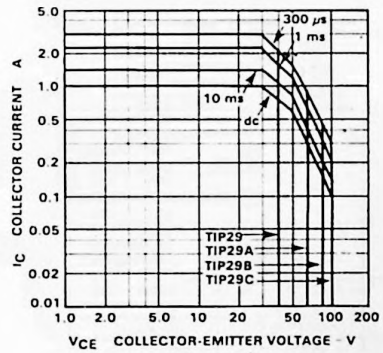
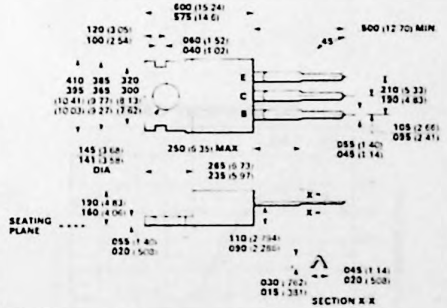
SAFE OPERATING AREA



JEDEC (TO-220) Outline**



NOTES
All dimensions in inches (bold) and millimeters (parentheses)
Package is silicone plastic with nickel-plated copper tab and pins
*Mechanically interchangeable with TO-66
Center pin is electrical contact with the mounting tab
Package weight is 2.1 grams
**Available in various pin configurations

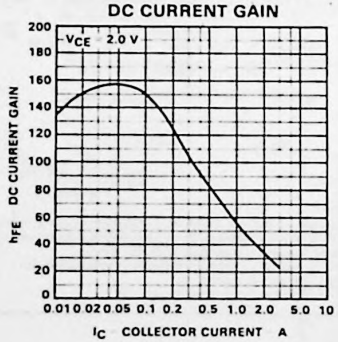
ELECTRICAL CHARACTERISTICS (25°C Case Temperature unless otherwise noted)

SYMBOL	CHARACTERISTIC	TIP29		TIP29A		TIP29B		TIP29C		UNIT	TEST CONDITIONS
		MIN	MAX	MIN	MAX	MIN	MAX	MIN	MAX		
OFF CHARACTERISTICS											
$V_{CEO(sus)}$	Collector-Emitter Sustaining Voltage (Note 1)	40		60		80		100		V	I_C = 30 mA, I_B = 0
I_{CEO}	Collector Cutoff Current		0.3		0.3					mA	V_{CE} = 30 V, I_B = 0
							0.3		0.3	mA	V_{CE} = 60 V, I_B = 0
I_{CES}	Collector Reverse Current		0.2							mA	V_{CE} = 40 V, V_{BE} = 0
					0.2					mA	V_{CE} = 60 V, V_{BE} = 0
							0.2			mA	V_{CE} = 80 V, V_{BE} = 0
									0.2	mA	V_{CE} = 100 V, V_{BE} = 0
I_{EBO}	Emitter Cutoff Current		1.0		1.0		1.0		1.0	mA	V_{EB} = 5.0 V, I_C = 0
ON CHARACTERISTICS											
h_{FE}	DC Current Gain (Note 1)	40		40		40		40			I_C = 0.2 A, V_{CE} = 4.0 V
		15	75	15	75	15	75	15	75		I_C = 1.0 A, V_{CE} = 4.0 V
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage (Note 1)		0.7		0.7		0.7		0.7	V	I_C = 1.0 A, I_B = 125 mA
$V_{BE(on)}$	Base-Emitter "On" Voltage (Note 1)		1.3		1.3		1.3		1.3	V	I_C = 1.0 A, V_{CE} = 4.0 V
DYNAMIC CHARACTERISTICS											
$\lvert h_{fe} \rvert$	Magnitude of Common Emitter Small Signal Current Gain	3.0		3.0		3.0		3.0			I_C = 0.2 A, V_{CE} = 10 V, f = 1.0 MHz
h_{fe}	Small Signal Current Gain	20		20		20		20			I_C = 0.2 A, V_{CE} = 10V, f = 1.0 kHz

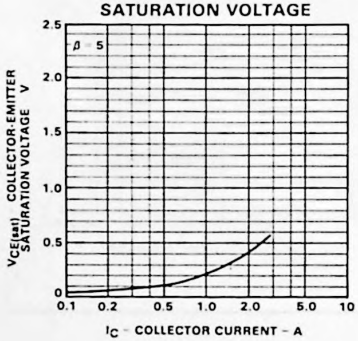
NOTE: 1. Pulse conditions: Length = 300 μs, Duty Cycle = 2%.

TYPICAL ELECTRICAL CHARACTERISTICS

DC CURRENT GAIN

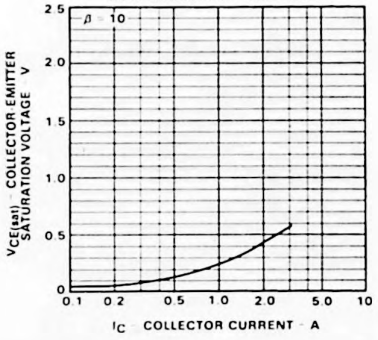


COLLECTOR-EMITTER SATURATION VOLTAGE

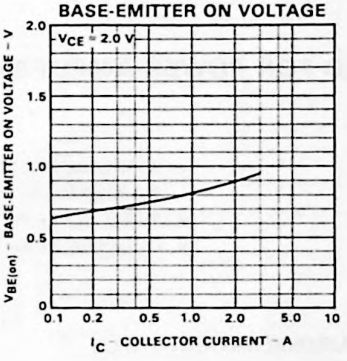


TYPICAL ELECTRICAL CHARACTERISTICS (Cont'd)

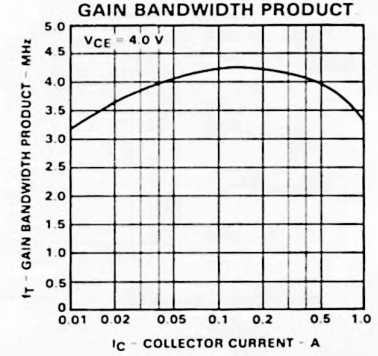
COLLECTOR-EMITTER SATURATION VOLTAGE



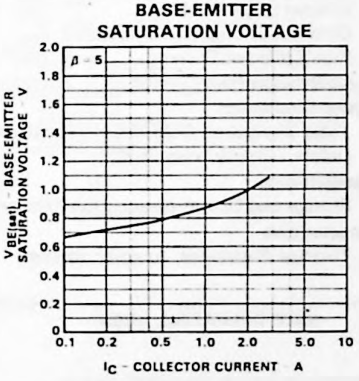
BASE-EMITTER ON VOLTAGE



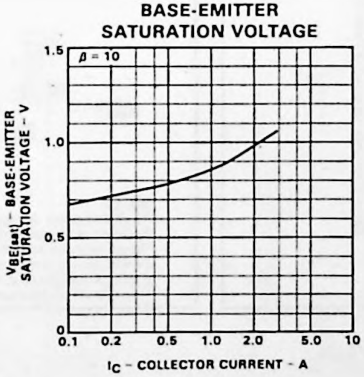
GAIN BANDWIDTH PRODUCT



BASE-EMITTER SATURATION VOLTAGE



BASE-EMITTER SATURATION VOLTAGE



6

POWER TRANSISTOR

PNP SILICON

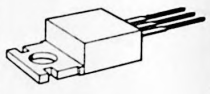
TIP30
TIP30A
TIP30B
TIP30C

DESIGNED FOR POWER AMPLIFIER AND HIGH SPEED SWITCHING APPLICATIONS

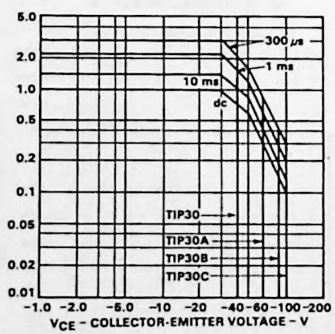
- 30 W DISSIPATION AT 25°C
- 1 A MAXIMUM CONTINUOUS COLLECTOR CURRENT
- 15 TO 75 h_{FE} AT I_C 1 A
- COMPLEMENTS TIP29, TIP29A, TIP29B, TIP29C

ABSOLUTE MAXIMUM RATINGS (Note 1)

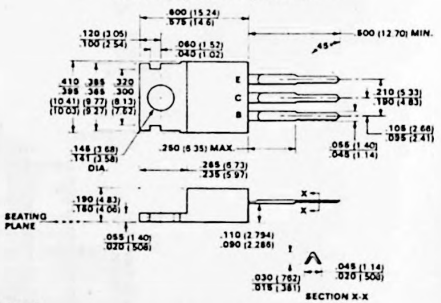
		TIP30	TIP30A	TIP30B	TIP30C
Maximum Voltages and Currents					
V_{CEO}	Collector to Emitter Voltage	-40 V	-60 V	-80 V	-100 V
V_{CBO}	Collector to Base Voltage	-40 V	-60 V	-80 V	-100 V
V_{EBO}	Emitter to Base Voltage	-5.0 V	-5.0 V	-5.0 V	-5.0 V
I_C	Continuous Collector Current	1.0 A	1.0 A	1.0 A	1.0 A
I_C	Peak Collector Current	3.0 A	3.0 A	3.0 A	3.0 A
I_B	Continuous Base Current	0.4 A	0.4 A	0.4 A	0.4 A
Maximum Power Dissipation					
P_D	Total Dissipation @ 25°C Case Temperature				30 W
	Derate Linearly from 25°C				0.24 W/°C
Maximum Temperatures					
T_J, T_{stg}	Storage and Operation Junction Temperatures				-65°C to +150°C
Thermal Characteristics					
$R_{\theta JC}$	Thermal Resistance, Junction to Case				4.16°C/W



SAFE OPERATING AREA



JEDEC (TO-220) Outline**



NOTES:
All dimensions in inches (bold) and millimeters (parentheses)
Package is silicone plastic with nickel-plated copper tab and pins
*Mechanically interchangeable with TO-66
Center pin is electrical contact with the mounting tab
Package weight is 2.1 grams
**Available in various pin configurations

ELECTRICAL CHARACTERISTICS (25 C Case Temperature unless otherwise noted)

SYMBOL	CHARACTERISTIC	TIP30		TIP30A		TIP30B		TIP30C		UNIT	TEST CONDITIONS
		MIN	MAX	MIN	MAX	MIN	MAX	MIN	MAX		
OFF CHARACTERISTICS											
$V_{CEO(sus)}$	Collector-Emitter Sustaining Voltage (Note 1)	-40		-60		-80		-100		V	I_C 30 mA, I_B 0
I_{CEO}	Collector Cutoff Current		0.3		0.3		0.3		0.3	mA mA	V_{CE} -30 V, I_B 0 V_{CE} -60 V, I_B 0
I_{CES}	Collector Reverse Current		0.2		0.2		0.2		0.2	mA mA mA mA	V_{CE} -40 V, V_{BE} 0 V_{CE} -60 V, V_{BE} 0 V_{CE} -80 V, V_{BE} 0 V_{CE} -100 V, V_{BE} 0
I_{EBO}	Emitter Cutoff Current		1.0		1.0		1.0		1.0	mA	V_{EB} -5.0 V, I_C 0
ON CHARACTERISTICS											
h_{FE}	DC Current Gain (Note 1)	40 15	75	40 15	75	40 15	75	40 15	75		I_C 0.2 A, V_{CE} -4.0 V I_C 1.0 A, V_{CE} -4.0 V
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage (Note 1)		-0.7		-0.7		-0.7		-0.7	V	I_C 1.0 A, I_B 125 mA
$V_{BE(on)}$	Base-Emitter "On" Voltage (Note 1)		-1.3		-1.3		-1.3		-1.3	V	I_C 1.0 A, V_{CE} -4.0 V
DYNAMIC CHARACTERISTICS											
$\|h_{fe}\|$	Magnitude of Common Emitter Small Signal Current Gain	3.0		3.0		3.0		3.0			I_C 0.2 A, V_{CE} -10 V, f 1.0 MHz
h_{fe}	Small Signal Current Gain	20		20		20		20			I_C 0.2 A, V_{CE} -10V, f 1.0 kHz

NOTE 1 Pulse conditions Length 300 μs, Duty Cycle 2%.

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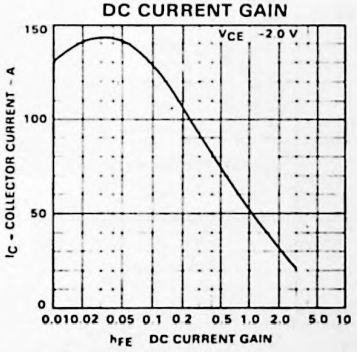
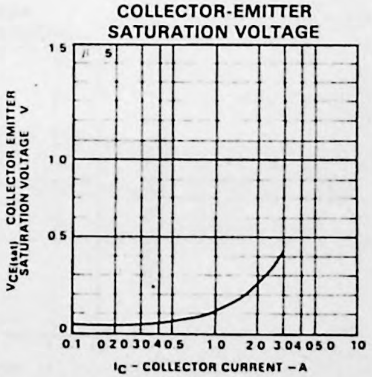
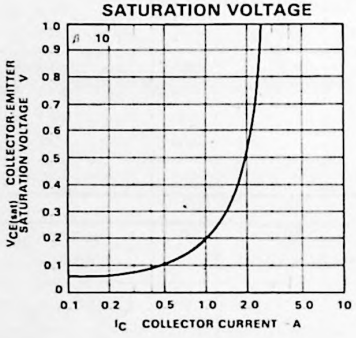
TYPICAL ELECTRICAL CHARACTERISTICS



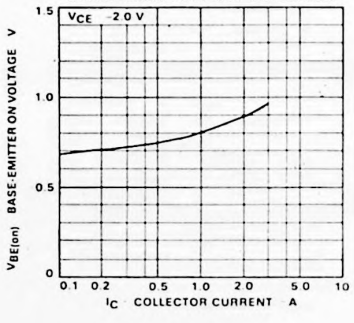


TYPICAL ELECTRICAL CHARACTERISTICS (Cont'd)

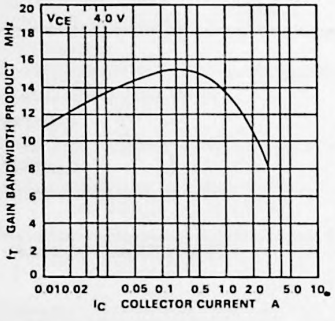
COLLECTOR-EMITTER SATURATION VOLTAGE



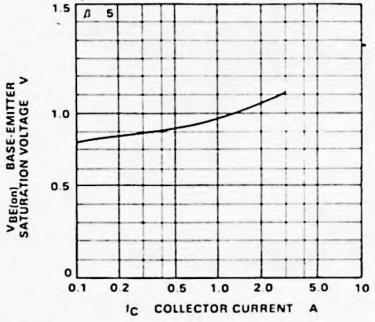
BASE-EMITTER ON VOLTAGE



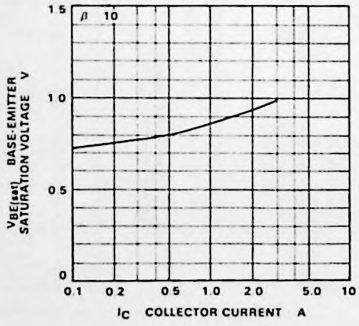
GAIN BANDWIDTH PRODUCT



BASE-EMITTER SATURATION VOLTAGE



BASE-EMITTER SATURATION VOLTAGE



POWER TRANSISTOR

NPN SILICON

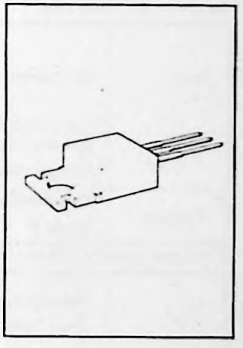
TIP31
TIP31A
TIP31B
TIP31C

DESIGNED FOR POWER AMPLIFIER AND HIGH SPEED SWITCHING APPLICATIONS

- 40 W DISSIPATION AT 25°C CASE
- 3.0 A MAXIMUM CONTINUOUS COLLECTOR CURRENT
- 10 TO 50 h_{FE} AT I_C 3.0 A
- COMPLEMENTS TIP32, TIP32A, TIP32B, TIP32C

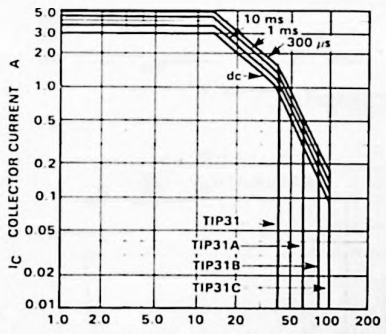
ABSOLUTE MAXIMUM RATINGS (Note 1)

		TIP31	TIP31A	TIP31B	TIP31C
Maximum Voltages and Currents					
V_{CEO}	Collector to Emitter Voltage	40 V	60 V	80 V	100 V
V_{CBO}	Collector to Base Voltage	40 V	60 V	80 V	100 V
V_{EBO}	Emitter to Base Voltage	5.0 V	5.0 V	5.0 V	5.0 V
I_C	Continuous Collector Current	3.0 A	3.0 A	3.0 A	3.0 A
I_C	Peak Collector Current	5.0 A	5.0 A	5.0 A	5.0 A
I_B	Continuous Base Current	1.0 A	1.0 A	1.0 A	1.0 A
Maximum Power Dissipation					
P_D	Total Dissipation @ 25°C Case Temperature				40 W
	Derate Linearly from 25°C				0.32 W/°C
Maximum Temperatures					
T_J, T_{stg}	Storage and Operation Junction Temperatures				−65°C to +150°C
Thermal Characteristics					
$R_{\theta JC}$	Thermal Resistance, Junction to Case				3.12°C/W

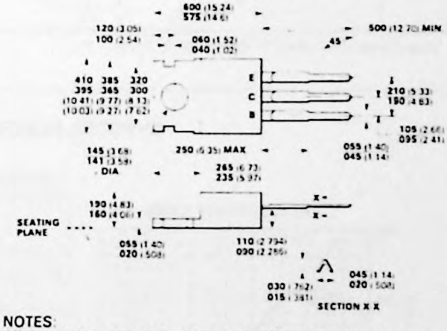


6

SAFE OPERATING AREA



JEDEC (TO-220) Outline**



NOTES:
All dimensions in inches (bold) and millimeters (parentheses)
Package is silicone plastic with nickel-plated copper tab and pins
*Mechanically interchangeable with TO-66
Center pin is electrical contact with the mounting tab
Package weight is 2.1 grams
**Available in various pin configurations

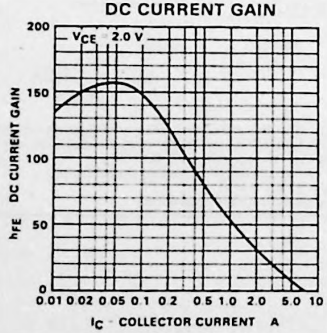
ELECTRICAL CHARACTERISTICS (25°C Case Temperature unless otherwise noted)

SYMBOL	CHARACTERISTIC	TIP31		TIP31A		TIP31B		TIP31C		UNIT	TEST CONDITIONS
		MIN	MAX	MIN	MAX	MIN	MAX	MIN	MAX		
OFF CHARACTERISTICS											
$V_{CEO(sus)}$	Collector-Emitter Sustaining Voltage (Note 1)	40		60		80		100		V	I_C = 30 mA, I_B = 0
I_{CEO}	Collector Cutoff Current		0.3		0.3					mA	V_{CE} = 30 V, I_B = 0
							0.3		0.3	mA	V_{CE} = 60 V, I_B = 0
I_{CES}	Collector Reverse Current		0.2							mA	V_{CE} = 40 V, V_{BE} = 0
					0.2					mA	V_{CE} = 60 V, V_{BE} = 0
							0.2			mA	V_{CE} = 80 V, V_{BE} = 0
									0.2	mA	V_{CE} = 100 V, V_{BE} = 0
I_{EBO}	Emitter Cutoff Current		1.0		1.0		1.0		1.0	mA	V_{EB} = 5.0 V, I_C = 0
ON CHARACTERISTICS											
h_{FE}	DC Current Gain (Note 1	25		25		25		25			I_C = 1.0 A, V_{CE} = 4.0 V
		10	50	10	50	10	50	10	50		I_C = 3.0 A, V_{CE} = 4.0 V
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage (Note 1)		1.2		1.2		1.2		1.2	V	I_C = 3.0 A, I_B = 375 mA
$V_{BE(on)}$	Base-Emitter "On" Voltage (Note 1)		1.8		1.8		1.8		1.8	V	I_C = 3.0 A, V_{CE} = 4.0 V
DYNAMIC CHARACTERISTICS											
$\|h_{fe}\|$	Magnitude of Common Emitter Small Signal Current Gain	3.0		3.0		3.0		3.0			I_C = 0.5 V, V_{CE} = 10 V, f = 1.0 MHz
h_{fe}	Small Signal Current Gain	20		20		20		20			I_C = 0.5 A, V_{CE} = 10 V, f = 1.0 kHz

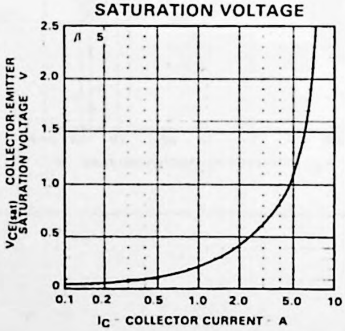
NOTE 1 Pulse conditions Length 300 μs, Duty Cycle 2%

TYPICAL ELECTRICAL CHARACTERISTICS

DC CURRENT GAIN

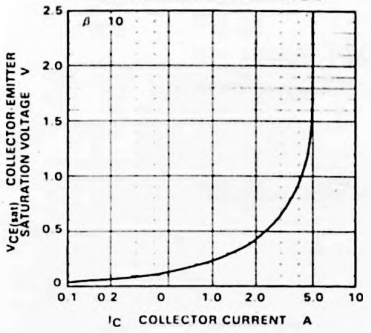


COLLECTOR-EMITTER SATURATION VOLTAGE

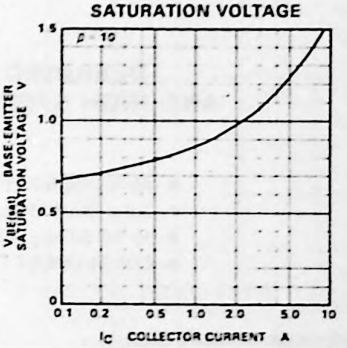


TYPICAL ELECTRICAL CHARACTERISTICS (Cont'd)

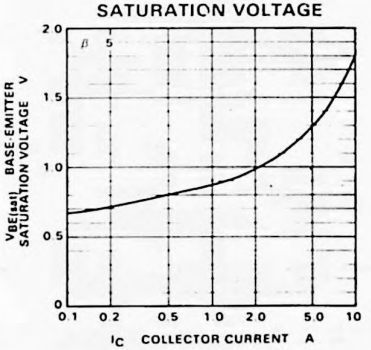
COLLECTOR-EMITTER SATURATION VOLTAGE



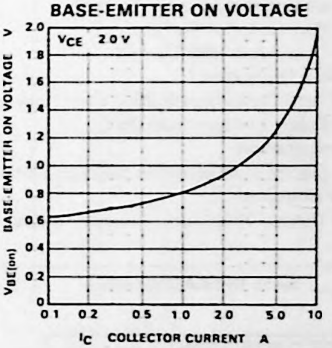
BASE-EMITTER SATURATION VOLTAGE



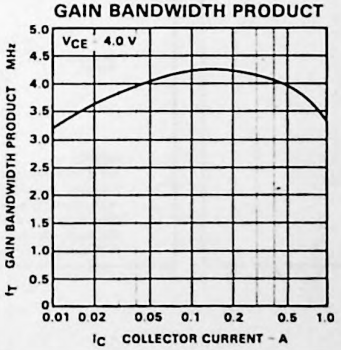
BASE-EMITTER SATURATION VOLTAGE



BASE-EMITTER ON VOLTAGE



GAIN BANDWIDTH PRODUCT



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POWER TRANSISTOR

PNP SILICON

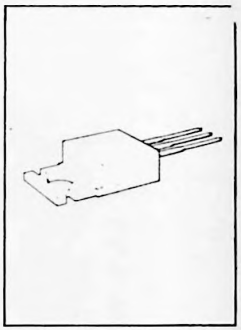
TIP32
TIP32A
TIP32B
TIP32C

DESIGNED FOR POWER AMPLIFIER AND HIGH SPEED SWITCHING APPLICATIONS

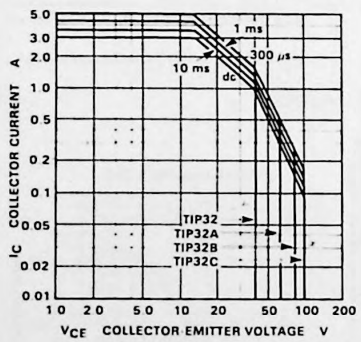
- 40 W DISSIPATION AT 25°C CASE
- 3.0 A MAXIMUM CONTINUOUS COLLECTOR CURRENT
- 10 TO 50 h_{FE} AT I_C 3.0 A
- COMPLEMENT TIP31, TIP31A, TIP31B, TIP31C

ABSOLUTE MAXIMUM RATINGS (Note 1)

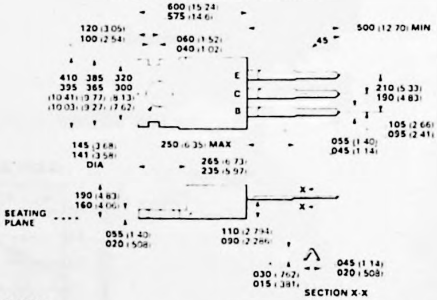
		TIP32	TIP32A	TIP32B	TIP32C
Maximum Voltages and Currents					
V_{CEO}	Collector to Emitter Voltage	−40 V	−60 V	−80 V	−100 V
V_{CBO}	Collector to Base Voltage	−40 V	−60 V	−80 V	−100 V
V_{EBO}	Emitter to Base Voltage	−5.0 V	−5.0 V	−5.0 V	−5.0 V
I_C	Continuous Collector Current	3.0 A	3.0 A	3.0 A	3.0 A
I_C	Peak Collector Current	5.0 A	5.0 A	5.0 A	5.0 A
I_B	Continuous Base Current	1.0 A	1.0 A	1.0 A	1.0 A
Maximum Power Dissipation					
P_D	Total Dissipation @ 25°C Case Temperature				40 W
	Derate Linearly from 25°C				0.32 W/°C
Maximum Temperatures					
T_J, T_{stg}	Storage and Operation Junction Temperatures				−65°C to +150°C
Thermal Characteristics					
$R_{\theta JC}$	Thermal Resistance, Junction to Case				3.12°C/W



SAFE OPERATING AREA



JEDEC (TO-220) Outline**



NOTES:
All dimensions in inches (bold) and millimeters (parentheses)
Package is silicone plastic with nickel-plated copper tab and pins
*Mechanically interchangeable with TO-66
Center pin is electrical contact with the mounting tab
Package weight is 2.1 grams
**Available in various pin configurations

ELECTRICAL CHARACTERISTICS (25 °C Case Temperature unless otherwise noted)

SYMBOL	CHARACTERISTIC	TIP 32		TIP 32A		TIP 32B		TIP 32C		UNIT	TEST CONDITIONS
		MIN	MAX	MIN	MAX	MIN	MAX	MIN	MAX		
OFF CHARACTERISTICS											
$V_{CEO(sus)}$	Collector-Emitter Sustaining Voltage (Note 1)	−40		−60		−80		−100		V	I_C = 30 mA, I_B = 0
I_{CEO}	Collector Cutoff Current		0.3		0.3					mA	V_{CE} = −30 V, I_B = 0
							0.3		0.3	mA	V_{CE} = −60 V, I_B = 0
I_{CES}	Collector Reverse Current		0.2							mA	V_{CE} = −40 V, V_{BE} = 0
					0.2					mA	V_{CE} = −60 V, V_{BE} = 0
							0.2			mA	V_{CE} = −80 V, V_{BE} = 0
									0.2	mA	V_{CE} = −100 V, V_{BE} = 0
I_{EBO}	Emitter Cutoff Current		1.0		1.0		1.0		1.0	mA	V_{EB} = −5.0 V, I_C = 0
ON CHARACTERISTICS											
h_{FE}	DC Current Gain (Note 1)	25		25		25		25			I_C = 1.0 A, V_{CE} = −4.0 V
		10	50	10	50	10	50	10	50		I_C = 3.0 A, V_{CE} = −4.0 A
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage (Note 1)		−1.2		−1.2		−1.2		−1.2	V	I_C = 3.0 A, I_B = 375 mA
$V_{BE(on)}$	Base-Emitter "On" Voltage (Note 1)		−1.8		−1.8		−1.8		−1.8	V	I_C = 3.0 A, V_{CE} = −4.0 V
DYNAMIC CHARACTERISTICS											
$\|h_{fe}\|$	Magnitude of Common Emitter Small Signal Current Gain	3.0		3.0		3.0		3.0			I_C = 0.5 A, V_{CE} = −10 V, f = 1.0 MHz
h_{fe}	Small Signal Current Gain	20		20		20		20			I_C = 0.5 A, V_{CE} = −10 V, f = 1.0 kHz

*NOTE 1. Pulse conditions: Length = 300 μs, Duty Cycle = 2%

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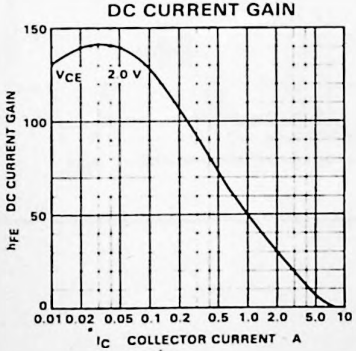
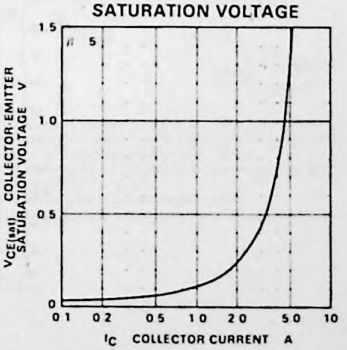
TYPICAL ELECTRICAL CHARACTERISTICS

DC CURRENT GAIN

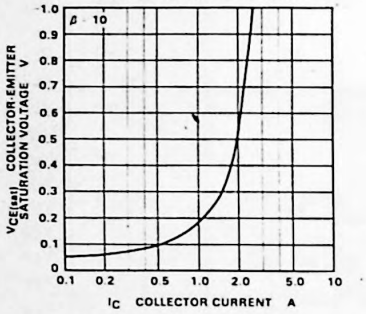


COLLECTOR-EMITTER SATURATION VOLTAGE

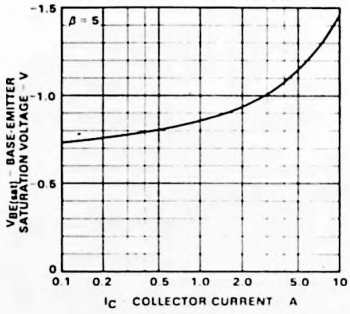


TYPICAL ELECTRICAL CHARACTERISTICS (Cont'd)

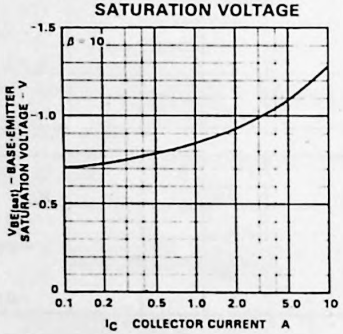
COLLECTOR-EMITTER SATURATION VOLTAGE



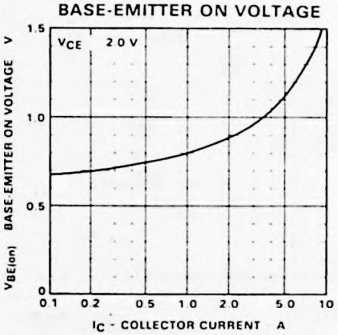
BASE-EMITTER SATURATION VOLTAGE



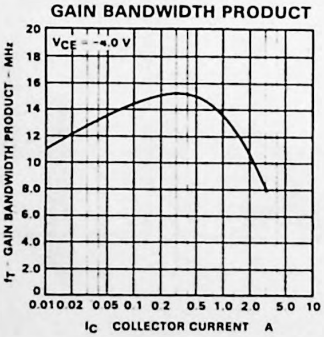
BASE-EMITTER SATURATION VOLTAGE



BASE-EMITTER ON VOLTAGE



GAIN BANDWIDTH PRODUCT



POWER TRANSISTOR

NPN SILICON

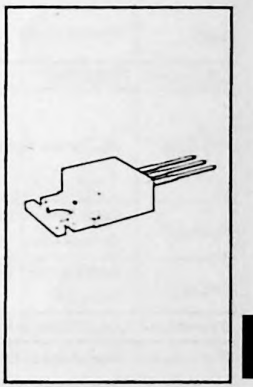
TIP41
TIP41A
TIP41B
TIP41C

DESIGNED FOR POWER AMPLIFIER AND HIGH SPEED SWITCHING APPLICATIONS

- 65 W DISSIPATION AT 25°C
- 6.0 A MAXIMUM CONTINUOUS COLLECTOR CURRENT
- 3.0 MHz MINIMUM f_T
- 0.7 s TYPICAL t_{off}
- COMPLEMENT TO TIP42 SERIES

ABSOLUTE MAXIMUM RATINGS (Note 1)

		TIP41	TIP41A	TIP41B	TIP41C
Maximum Voltages and Currents					
V_{CEO}	Collector to Emitter Voltage	40 V	60 V	80 V	100 V
V_{CBO}	Collector to Base Voltage	40 V	60 V	80 V	100 V
V_{EBO}	Emitter to Base Voltage	5.0 V	5.0 V	5.0 V	5.0 V
I_C	Continuous Collector Current	6.0 A	6.0 A	6.0 A	6.0 A
I_C	Peak Collector Current	10 A	10 A	10 A	10 A
I_B	Continuous Base Current	3.0 A	3.0 A	3.0 A	3.0 A
Maximum Power Dissipation					
P_D	Total Dissipation @ 25°C Case Temperature				65 W
	Derate Linearly from 25°C				0.52 W/°C
Maximum Temperatures					
T_J, T_{stg}	Storage and Operation Junction Temperatures				−65°C to +150°C
Thermal Characteristics					
$R_{\theta JC}$	Thermal Resistance, Junction to Case				1.92°C/W
T_P	Maximum Pin Temperature for Soldering Purposes: 1/8" from Case for 5 seconds				260°C



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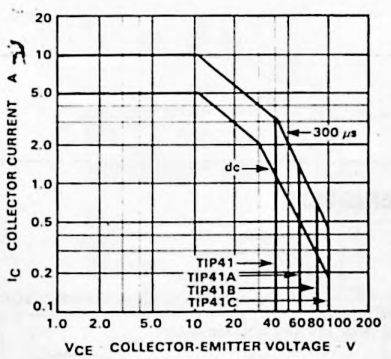
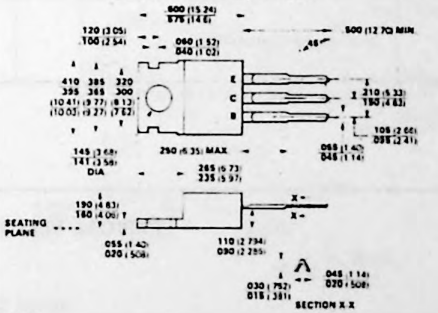
SAFE OPERATING AREA



JEDEC (TO-220) Outline**



NOTES:
All dimensions in inches (bold) and millimeters (parentheses)
Package is silicone plastic with nickel-plated copper tab and pins
*Mechanically interchangeable with TO-66
Center pin is electrical contact with the mounting tab
Package weight is 2.1 grams
**Available in various pin configurations

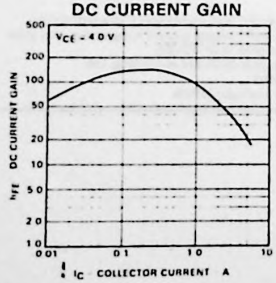
ELECTRICAL CHARACTERISTICS (25°C Case Temperature unless otherwise noted)

SYMBOL	CHARACTERISTIC	TIP41		TIP41A		TIP41B		TIP41C		UNIT	TEST CONDITIONS
		MIN	MAX	MIN	MAX	MIN	MAX	MIN	MAX		
OFF CHARACTERISTICS											
$V_{CEO(sus)}$	Collector-Emitter Sustaining Voltage (Note 1)	40		60		80		100		V	I_C = 30 mA, I_B = 0
I_{CEO}	Collector Cutoff Current		0.7		0.7					mA	V_{CE} = 30 V, I_B = 0
							0.7		0.7	mA	V_{CE} = 60 V, I_B = 0
I_{CES}	Collector Reverse Current		0.4							mA	V_{CE} = 40 V, V_{BE} = 0
					0.4					mA	V_{CE} = 60 V, V_{BE} = 0
							0.4			mA	V_{CE} = 80 V, V_{BE} = 0
									0.4	mA	V_{CE} = 100 V, V_{BE} = 0
I_{EBO}	Emitter Cutoff Current		1.0		1.0		1.0		1.0	mA	V_{EB} = 5.0 V, I_C = 0
ON CHARACTERISTICS											
h_{FE}	DC Current Gain (Note 1)	30		30		30		30			I_C = 0.3 A, V_{CE} = 4.0 V
		15	75	15	75	15	75	15	75		I_C = 3.0 A, V_{CE} = 4.0 V
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage (Note 1)		1.5		1.5		1.5		1.5	V	I_C = 6.0 A, I_B = 0.6 A
$V_{BE(on)}$	Base-Emitter "On" Voltage (Note 1)		2.0		2.0		2.0		2.0	V	I_C = 6.0 A, V_{CE} = 4.0 V
DYNAMIC CHARACTERISTICS											
$\lvert h_{fe} \rvert$	Magnitude of Common Emitter Small Signal Short Circuit Forward Current Transfer Ratio	3.0		3.0		3.0		3.0			I_C = 0.5 A, V_{CE} = 10 V, f = 1.0 MHz
h_{fe}	Small Signal Current Gain	20		20		20		20			I_C = 0.5 A, V_{CE} = 10 V, f = 1.0 kHz

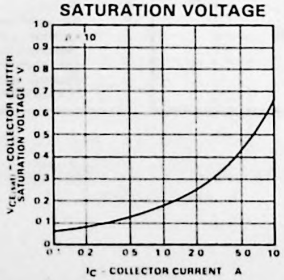
NOTE 1 Pulse conditions Length 300 μs, Duty Cycle 2%.

TYPICAL ELECTRICAL CHARACTERISTICS

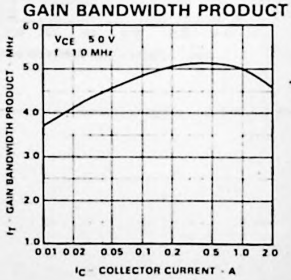
DC CURRENT GAIN



COLLECTOR-EMITTER SATURATION VOLTAGE



GAIN BANDWIDTH PRODUCT



POWER TRANSISTOR

PNP SILICON

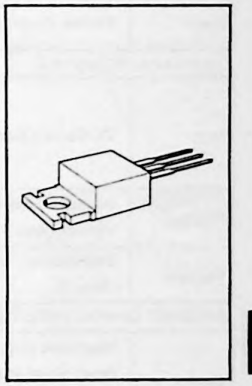
TIP 42
TIP 42A
TIP 42B
TIP 42C

DESIGNED FOR POWER AMPLIFIER AND HIGH SPEED SWITCHING APPLICATIONS

- 65 W DISSIPATION AT 25°C CASE
- 6.0 A MAXIMUM CONTINUOUS COLLECTOR CURRENT
- 3.0 MHz MINIMUM f_T
- 0.7 s TYPICAL t_{off}
- COMPLEMENT TO TIP41 SERIES

ABSOLUTE MAXIMUM RATINGS (Note 1)

		TIP42	TIP42A	TIP42B	TIP42C
Maximum Voltages and Currents					
V_{CEO}	Collector to Emitter Voltage	–40 V	–60 V	–80 V	–100 V
V_{CBO}	Collector to Base Voltage	–40 V	–60 V	–80 V	–100 V
V_{EBO}	Emitter to Base Voltage	–5.0 V	–5.0 V	–5.0 V	–5.0 V
I_C	Continuous Collector Current	6.0 A	6.0 A	6.0 A	6.0 A
I_C	Peak Collector Current	10 A	10 A	10 A	10 A
I_B	Continuous Base Current	3.0 A	3.0 A	3.0 A	3.0 A
Maximum Power Dissipation					
P_D	Total Dissipation @ 25°C Case Temperature				65 W
	Derate Linearly from 25°C				0.52 W/°C
Maximum Temperatures					
T_J, T_{stg}	Storage and Operation Junction Temperatures				–65°C to +150°C
Thermal Characteristics					
$R_{\theta JC}$	Thermal Resistance, Junction to Case				1.92°C/W
T_P	Maximum Pin Temperature for Soldering Purposes: 1/8" from Case for 5 seconds				260°C



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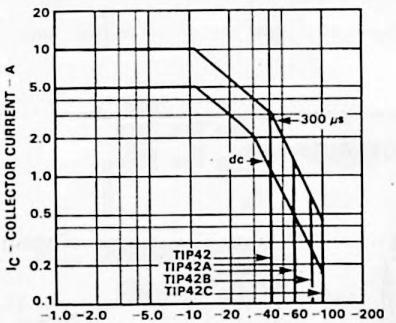
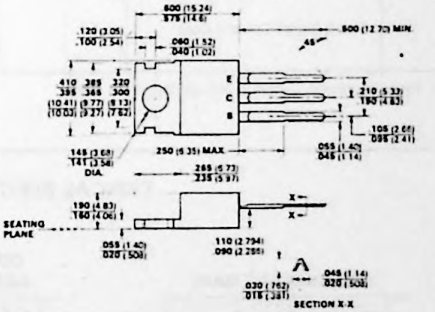
SAFE OPERATING AREA



JEDEC (TO-220) Outline**



NOTES:
All dimensions in inches (bold) and millimeters (parentheses)
Package is silicone plastic with nickel-plated copper tab and pins
*Mechanically interchangeable with TO-66
Center pin is electrical contact with the mounting tab
Package weight is 2.1 grams
**Available in various pin configurations

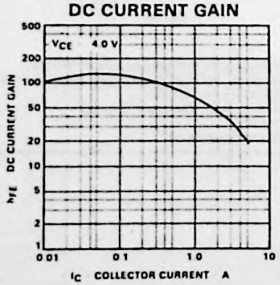
ELECTRICAL CHARACTERISTICS (25°C Case Temperature unless otherwise noted)

SYMBOL	CHARACTERISTIC	TIP 42		TIP 42A		TIP 42B		TIP 42C		UNIT	TEST CONDITIONS
		MIN	MAX	MIN	MAX	MIN	MAX	MIN	MAX		
OFF CHARACTERISTICS											
$V_{CEO(sus)}$	Collector-Emitter Sustaining Voltage (Note 1)	−40		−60		−80		−100		V	I_C = 30 mA, I_B = 0
I_{CEO}	Collector Cutoff Current		0.7		0.7					mA	V_{CE} = −30 V, I_B = 0
							0.7		0.7	mA	V_{CE} = −60 V, I_B = 0
I_{CES}	Collector Reverse Current		−0.4							mA	V_{CE} = −40 V, V_{BE} = 0
					−0.4					mA	V_{CE} = −60 V, V_{BE} = 0
							−0.4			mA	V_{CE} = −80 V, V_{BE} = 0
									−0.4	mA	V_{CE} = −100 V, V_{BE} = 0
I_{EBO}	Emitter Cutoff Current		1.0		1.0		1.0		1.0	mA	V_{EB} = −5.0 V, I_C = 0
ON CHARACTERISTICS											
h_{FE}	DC Current Gain (Note 1)	30		30		30		30			I_C = 0.3 A, V_{CE} = −4.0 V
		15	75	15	75	15	75	15	75		I_C = 3.0 A, V_{CE} = −4.0 V
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage (Note 1)		−1.5		−1.5		−1.5		−1.5	V	I_C = 6.0 A, I_B = 0.6 A
$V_{BE(on)}$	Base-Emitter "On" Voltage (Note 1)		−2.0		−2.0		−2.0		−2.0	V	I_C = 6.0 A, V_{CE} = −4.0 V
DYNAMIC CHARACTERISTICS											
$\lvert h_{fe} \rvert$	Magnitude of Common Emitter Small Signal Short Circuit Forward Current Transfer Ratio	3.0		3.0		3.0		3.0			I_C = 0.5 A, V_{CE} = −10 V, f = 1.0 MHz
h_{fe}	Small Signal Current Gain	20		20		20		20			I_C = 0.5 A, V_{CE} = −10 V, f = 1.0 kHz

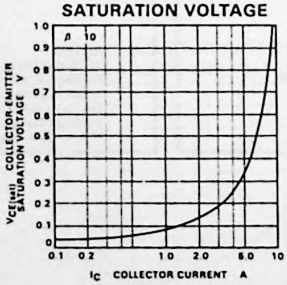
NOTE: 1. Pulse conditions: Length = 300 μs, Duty Cycle = 2%.

TYPICAL ELECTRICAL CHARACTERISTICS

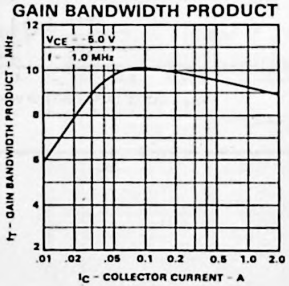
DC CURRENT GAIN



COLLECTOR-EMITTER SATURATION VOLTAGE



GAIN BANDWIDTH PRODUCT



POWER TRANSISTOR

NPN SILICON

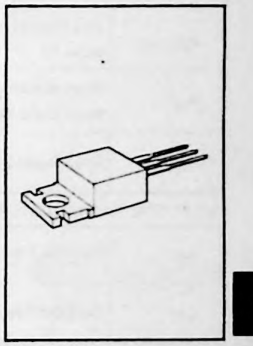
TIP61
TIP61A
TIP61B
TIP61C

DESIGNED FOR POWER AMPLIFIER AND HIGH SPEED SWITCHING APPLICATIONS

- 15 W DISSIPATION AT 25°C CASE
- 0.5 A MAXIMUM CONTINUOUS COLLECTOR CURRENT
- 3.0 MHz MINIMUM f_T
- 0.7 μs TYPICAL t_{off}
- COMPLEMENT TO TIP62 SERIES

ABSOLUTE MAXIMUM RATINGS (Note 1)

Maximum Voltages and Currents		TIP61	TIP61A	TIP61B	TIP61C
V_{CEO}	Collector to Emitter Voltage	40 V	60 V	80 V	100 V
V_{CBO}	Collector to Base Voltage	40 V	60 V	80 V	100 V
V_{EBO}	Emitter to Base Voltage	5.0 V	5.0 V	5.0 V	5.0 V
I_C	Continuous Collector Current	0.5 A	0.5 A	0.5 A	0.5 A
I_C	Peak Collector Current	1.5 A	1.5 A	1.5 A	1.5 A
I_B	Continuous Base Current	0.4 A	0.4 A	0.4 A	0.4 A
Maximum Power Dissipation					
P_D	Total Dissipation @25°C Case Temperature				15 W
	Derate Linearly from 25°C				0.12 W/°C
Maximum Temperatures					
T_J, T_{stg}	Storage and Operation Junction Temperatures				−65°C to +150°C
Thermal Characteristics					
$R_{\theta JC}$	Thermal Resistance, Junction to Case				8.34°C/W
T_P	Maximum Pin Temperature (Soldering, 10 s)				260°C



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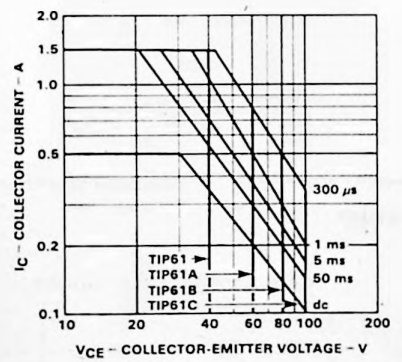
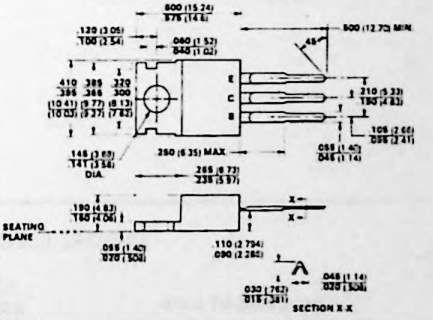
SAFE OPERATING AREA



JEDEC (TO-220) Outline**



NOTES:
All dimensions in inches (bold) and millimeters (parentheses)
Package is silicone plastic with nickel-plated copper tab and pins
*Mechanically interchangeable with TO-66
Center pin is electrical contact with the mounting tab
Package weight is 2.1 grams
**Available in various pin configurations

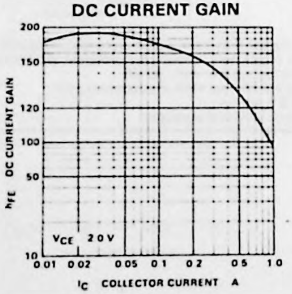
ELECTRICAL CHARACTERISTICS (25°C Case Temperature unless otherwise noted)

SYMBOL	CHARACTERISTIC	TIP61		TIP61A		TIP62B		TIP62C		UNIT	TEST CONDITIONS
		MIN	MAX	MIN	MAX	MIN	MAX	MIN	MAX		
OFF CHARACTERISTICS											
$V_{CEO(sus)}$	Collector-Emitter Sustaining Voltage (Note 1)	40		60		80		100		V	I_C = 30 mA, I_B = 0
I_{CEO}	Collector Cutoff Current		0.3		0.3					mA	V_{CE} = 30 V, I_B = 0
							0.3		0.3	mA	V_{CE} = 60 V, I_B = 0
I_{CES}	Collector Reverse Current		0.2							mA	V_{CE} = 40 V, V_{BE} = 0
					0.2					mA	V_{CE} = 60 V, V_{BE} = 0
							0.2			mA	V_{CE} = 80 V, V_{BE} = 0
									0.2	mA	V_{CE} = 100 V, V_{BE} = 0
I_{EBO}	Emitter Cutoff Current		1.0		1.0		1.0		1.0	mA	V_{EB} = 5.0 V, I_C = 0
ON CHARACTERISTICS											
h_{FE}	DC Current Gain (Note 1)	40 15	100	40 15	100	40 15	100	40 15	100		I_C = 50 mA, V_{CE} = 4.0 V I_C = 0.5 A, V_{CE} = 4.0 V
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage (Note 1)		0.7		0.7		0.7		0.7	V	I_C = 0.5 A, I_B = 60 mA
$V_{BE(on)}$	Base-Emitter "On" Voltage (Note 1)		1.3		1.3		1.3		1.3	V	I_C = 0.5 A, V_{CE} = 4.0 V
$\lvert h_{fe} \rvert$	Magnitude of Common Emitter Small Signal Current Gain	3.0		3.0		3.0		3.0			I_C = 50 mA, V_{CE} = 10 V, f = 1.0 MHz
h_{fe}	Small Signal Current Gain	20		20		20		20			I_C = 50 mA, V_{CE} = 10 V, f = 1.0 kHz
SWITCHING CHARACTERISTICS											
t_{on}	Turn On Time	0.12 typ		0.12 typ		0.12 typ		0.12 typ		μs	I_C = 0.5 V, $V_{BE(off)}$ = −4.2 V I_{B1} = 60 mA
t_{off}	Turn Off Time	0.7 typ		0.7 typ		0.7 typ		0.7 typ		μs	I_C = 0.5 A, $V_{BE(off)}$ = −4.2 V I_{B1} = I_{B2} = 60 mA

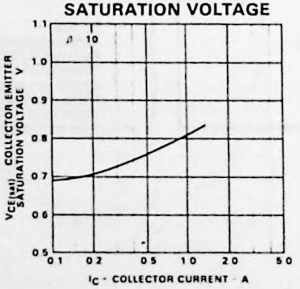
NOTE: 1. Pulse conditions: Length = 300 μs, Duty Cycle = 2%.

TYPICAL ELECTRICAL CHARACTERISTICS

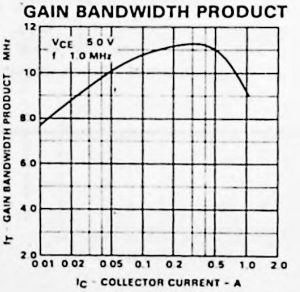
DC CURRENT GAIN



COLLECTOR-EMITTER SATURATION VOLTAGE



GAIN BANDWIDTH PRODUCT



POWER TRANSISTOR

PNP SILICON

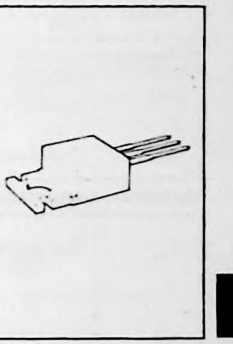
TIP62
TIP62A
TIP62B
TIP62C

DESIGNED FOR POWER AMPLIFIER AND HIGH SPEED SWITCHING APPLICATIONS

- 15 W DISSIPATION AT 25°C CASE
- 3.0 MHz MINIMUM f_T
- 0.7 μs TYPICAL t_{off}
- COMPLEMENT TO TIP61 SERIES

ABSOLUTE MAXIMUM RATINGS (Note 1)

		TIP62	TIP62A	TIP62B	TIP62C
Maximum Voltages and Currents					
V_{CEO}	Collector to Emitter Voltage	−40 V	−60 V	−80 V	−100 V
V_{CBO}	Collector to Base Voltage	−40 V	−60 V	−80 V	−100 V
V_{EBO}	Emitter to Base Voltage	−5.0 V	−5.0 V	−5.0 V	−5.0 V
I_C	Continuous Collector Current	0.5 A	0.5 A	0.5 A	0.5 A
I_C	Peak Collector Current	1.5 A	1.5 A	1.5 A	1.5 A
I_B	Continuous Base Current	0.4 A	0.4 A	0.4 A	0.4 A
Maximum Power Dissipation					
P_D	Total Dissipation @ 25°C Case Temperature (Note 1)				15 W
	Derate Linearly from 25°C				120 MW/°C
Maximum Temperatures					
T_J, T_{stg}	Storage and Operation Junction Temperatures				−65°C to +150°C
Thermal Characteristics					
$R_{\theta JC}$	Thermal Resistance, Junction to Case				8.34°C/W
T_P	Maximum Pin Temperature for Soldering Purposes: 1/8" from Case for 10 seconds				260°C



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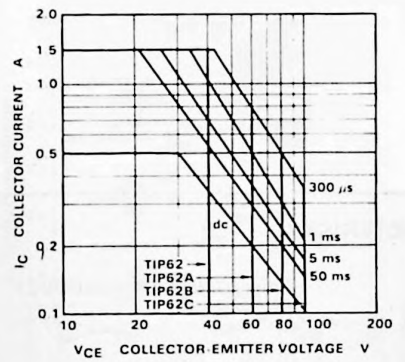
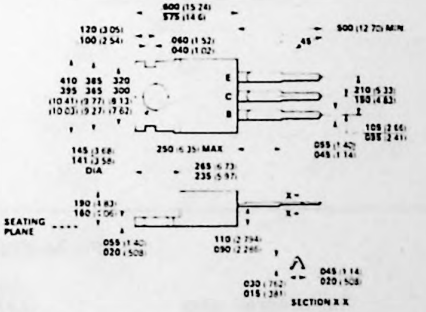
SAFE OPERATING AREA



JEDEC (TO-220) Outline**



NOTES
All dimensions 62 inches (bold) and millimeters (parentheses)
Package is silicone plastic with nickel-plated copper tab and pins
*Mechanically interchangeable with TO-66
Center pin is electrical contact with the mounting tab
Package weight is 2.1 grams
**Available in various pin configurations

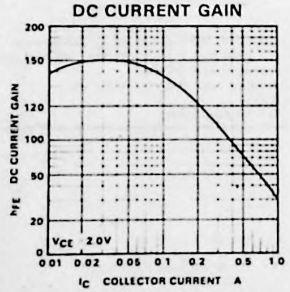
ELECTRICAL CHARACTERISTICS (25° C Case Temperature unless otherwise noted)

SYMBOL	CHARACTERISTIC	TIP62		TIP62A		TIP62B		TIP62C		UNIT	TEST CONDITIONS
		MIN	MAX	MIN	MAX	MIN	MAX	MIN	MAX		
OFF CHARACTERISTICS											
$V_{CEO(sus)}$	Collector-Emitter Sustaining Voltage (Note 1)	40		60		80		100		V	I_C = 30 mA, I_B = 0
I_{CEO}	Collector Cutoff Current		0.3		0.3		0.3		0.3	mA mA	V_{CE} = −30 V, I_B = 0 V_{CE} = −60 V, I_B = 0
I_{CES}	Collector Reverse Current		0.2		0.2		0.2		0.2	mA mA mA mA	V_{CE} = −40 V, V_{BE} = 0 V_{CE} = −60 V, V_{BE} = 0 V_{CE} = −80 V, V_{BE} = 0 V_{CE} = −100 V, V_{BE} = 0
I_{EBO}	Emitter Cutoff Current		1.0		1.0		1.0		1.0	mA	V_{EB} = −5.0 V, I_C = 0
ON CHARACTERISTICS											
h_{FE}	DC Current Gain (Note 1)	40 15	100	40 15	100	40 15	100	40 15	100		I_C = 50 mA, V_{CE} = −4.0 V I_C = 0.5 A, V_{CE} = −4.0 V
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage (Note 1)		0.7		0.7		0.7		0.7	V	I_C = 0.5 A, I_B = 60 mA
$V_{BE(on)}$	Base-Emitter "On" Voltage (Note 1)		1.3		1.3		1.3		1.3	V	I_C = 0.5 A, V_{CE} = −4.0 V
DYNAMIC CHARACTERISTICS											
$\|h_{fe}\|$	Magnitude of Common Emitter Small Signal Current Gain	3.0		3.0		3.0		3.0			I_C = 50 mA, V_{CE} = −10 V, f = 1.0 MHz
h_{fe}	Small Signal Current Gain	20		20		20		20			I_C = 50 mA, V_{CE} = −10 V, f = 1.0 kHz
SWITCHING CHARACTERISTICS											
t_{on}	Turn On Time	0.12 Typ		0.12 Typ		0.12 Typ		0.12 Typ		μs	I_C = 0.5 A, $V_{BE(off)}$ = −4.2 V I_{B1} = 60 mA
t_{off}	Turn Off Time	1.0 Typ		1.0 Typ		1.0 Typ		1.0 Typ		μs	I_C = 0.5 A, $V_{BE(off)}$ = −4.2 V I_{B1} = I_{B2} = 60 mA

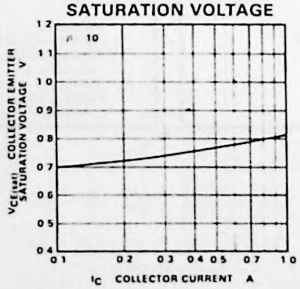
NOTES: (1) Pulse conditions: Length = 300 μs, Duty Cycle = 2%.

TYPICAL ELECTRICAL CHARACTERISTIC

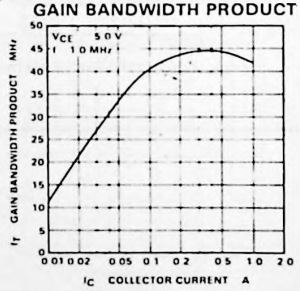
DC CURRENT GAIN



COLLECTOR-EMITTER SATURATION VOLTAGE



GAIN BANDWIDTH PRODUCT



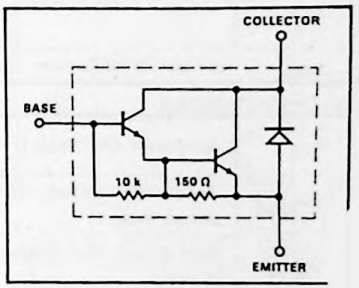
POWER TRANSISTOR

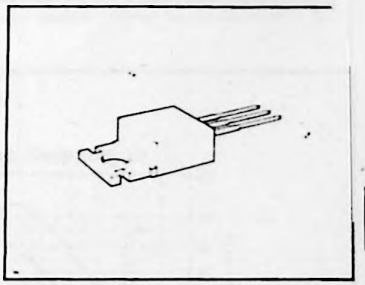
NPN SILICON

TIP110
TIP111
TIP112

GENERAL PURPOSE DARLINGTON SUITABLE FOR POWER AMPLIFIER AND SWITCHING APPLICATIONS

- 50 W DISSIPATION AT 25°C CASE
- 2.0 A MAXIMUM CONTINUOUS COLLECTOR CURRENT
- h_{FE} TYPICAL OF 3000 AT 1.0 A
- COMPLEMENT TO TIP115, TIP116, TIP117



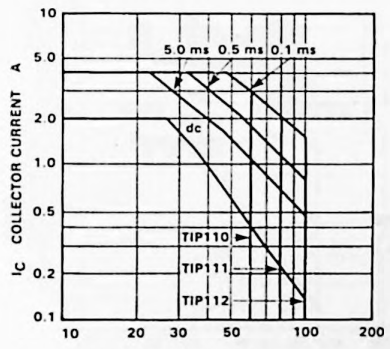


ABSOLUTE MAXIMUM RATINGS

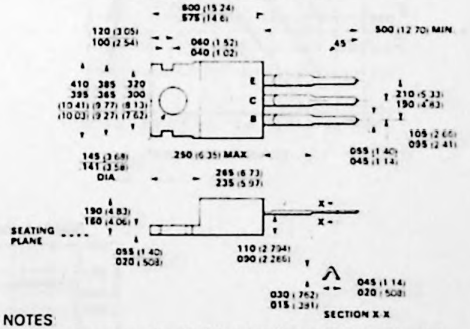
		TIP110	TIP111	TIP112
Maximum Voltages and Currents				
V_{CE}	Collector to Emitter Voltage	60 V	80 V	100 V
V_{CB}	Collector to Base Voltage	60 V	80 V	100 V
V_{EB}	Emitter to Base Voltage	5.0 V	5.0 V	5.0 V
I_C	Continuous Collector Current	2.0 A	2.0 A	2.0 A
I_C	Peak Collector Current	4.0 A	4.0 A	4.0 A
I_B	Continuous Base Current	0.05 A	0.05 A	0.05 A
Maximum Power Dissipation				
P_D	* Total Dissipation @ 25°C Case Temperature			50 W
	Derate Linearly from 25°C			0.4 W/°C
Maximum Temperatures				
T_J, T_{stg}	Storage and Operation Junction Temperatures			−65°C to +150°C
Thermal Characteristics				
$R_{\theta JC}$	Thermal Resistance, Junction to Case			2.5 °C/W
T_P	Maximum Pin Temperature (Soldering, 5 s)			260°C

6

SAFE OPERATING AREA



JEDEC (TO-220) Outline*



NOTES
All dimensions in inches (bold) and millimeters (parentheses)
Package is silicone plastic with nickel-plated copper tab and pins
Center pin is electrical contact with the mounting tab
Package weight is 2.1 grams
*Available in various pin configurations

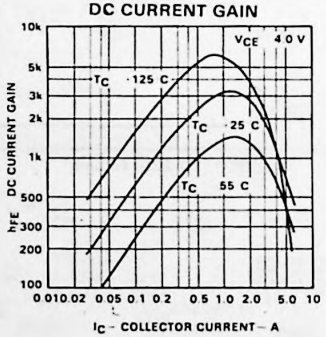
ELECTRICAL CHARACTERISTICS (25°C Case Temperature unless otherwise noted)

SYMBOL	CHARACTERISTIC	TIP110		TIP111		TIP112		UNITS	TEST CONDITIONS
		MIN	MAX	MIN	MAX	MIN	MAX		
OFF CHARACTERISTICS									
$V_{CEO(sus)}$	Collector-Emitter Sustaining Voltage (Note 1)	60		80		100		V	I_C = 30 mA, I_B = 0
I_{CEO}	Collector Cutoff Current		2.0		2.0			mA	V_{CE} = 30 V, I_B = 0
							2.0	mA	V_{CE} = 40 V, I_B = 0
								mA	V_{CE} = 50 V, I_B = 0
I_{CBO}	Collector Cutoff Current		1.0		1.0			mA	V_{CB} = 60 V, I_E = 0
							1.0	mA	V_{CB} = 80 V, I_E = 0
								mA	V_{CB} = 100 V, I_E = 0
I_{EBO}	Emitter Cutoff Current		2.0		2.0		2.0	mA	V_{EB} = 5.0 V, I_C = 0
ON CHARACTERISTICS									
h_{FE}	DC Current Gain (Note 1)	1k		1k		1k			I_C = 1.0 A, V_{CE} = 4.0 V
		500		500		500			I_C = 2.0 A, V_{CE} = 4.0 V
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage (Note 1)		2.5		2.5		2.5	V	I_C = 2.0 A, I_B = 8.0 mA
$V_{BE(on)}$	Base-Emitter "On" Voltage (Note 1)		2.8		2.8		2.8	V	I_C = 2.0 A, V_{CE} = 4.0 V

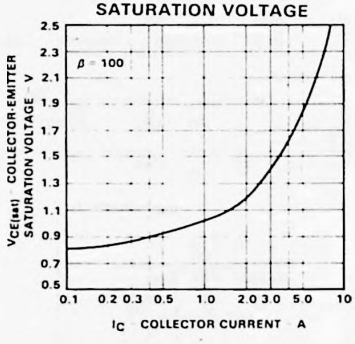
NOTE 1 Pulse conditions: Length = 300 μs, Duty Cycle = 2%.

TYPICAL ELECTRICAL CHARACTERISTICS

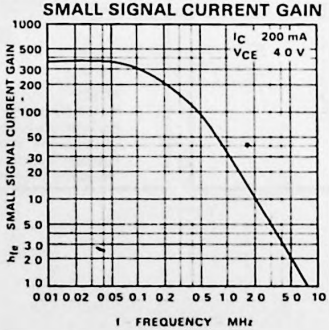
DC CURRENT GAIN



COLLECTOR-EMITTER SATURATION VOLTAGE



SMALL SIGNAL CURRENT GAIN



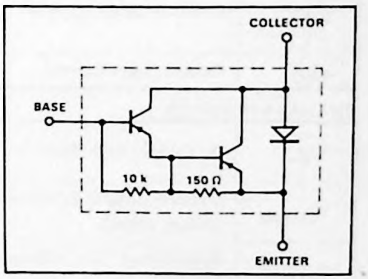
POWER DARLINGTON

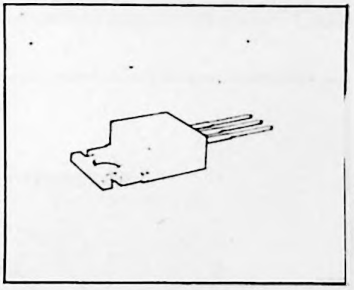
PNP SILICON

TIP115
TIP116
TIP117

GENERAL PURPOSE DARLINGTON SUITABLE FOR POWER AMPLIFIER AND SWITCHING APPLICATIONS

- 50 W DISSIPATION AT 25°C CASE
- 2.0 A MAXIMUM CONTINUOUS COLLECTOR CURRENT
- h_{FE} TYPICAL OF 3000 AT 1.0 A
- COMPLEMENTS TO TIP110, TIP111, TIP112





ABSOLUTE MAXIMUM RATINGS

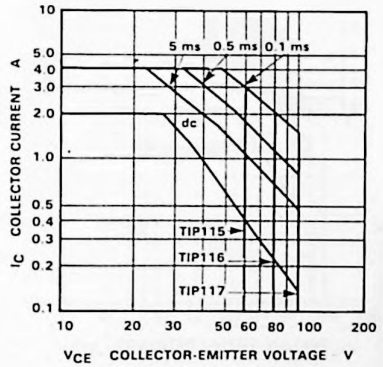
Maximum Voltages and Currents		TIP115	TIP116	TIP117
V_{CE}	Collector to Emitter Voltage	−60 V	−80 V	−100 V
V_{CB}	Collector to Base Voltage	−60 V	−80 V	−100 V
V_{EB}	Emitter to Base Voltage	−5.0 V	−5.0 V	−5.0 V
I_C	Continuous Collector Current	2.0 A	2.0 A	2.0 A
I_C	Peak Collector Current	4.0 A	4.0 A	4.0 A
I_B	Continuous Base Current	0.05 A	0.05 A	0.05 A

Maximum Power Dissipation		
P_D	Total Dissipation @ 25°C Case Temperature	50 W
	Derate Linearly from 25°C	0.4 W/°C

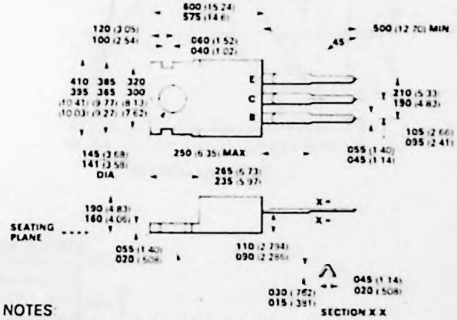
Maximum Temperatures		
T_J, T_{stg}	Storage and Operation Junction Temperatures	−65°C to +150°C

Thermal Characteristics		
$R_{\theta JC}$	Thermal Resistance, Junction to Case	2.5 °C/W
T_P	Maximum Pin Temperature (Soldering, 10 s)	260°C

SAFE OPERATING AREA



JEDEC (TO-220) Outline*



NOTES:
All dimensions in inches (bold) and millimeters (parentheses)
Package is silicone plastic with nickel-plated copper tab and pins
Center pin is electrical contact with the mounting tab
Package weight is 2.1 grams
*Available in various pin configurations

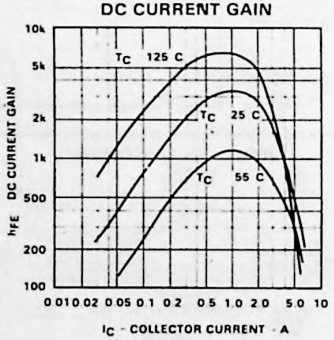
ELECTRICAL CHARACTERISTICS (25°C Case Temperature unless otherwise noted)

SYMBOL	CHARACTERISTIC	TIP115		TIP116		TIP117		UNITS	TEST CONDITIONS
		MIN	MAX	MIN	MAX	MIN	MAX		
OFF CHARACTERISTICS									
$V_{CEO(sus)}$	Collector-Emitter Sustaining Voltage (Note 1)	−60		−80		−100		V	I_C = 30 mA, I_B = 0
I_{CEO}	Collector Cutoff Current		2.0		2.0			mA	V_{CE} = −30 V, I_B = 0
							2.0	mA	V_{CE} = −40 V, I_B = 0
								mA	V_{CE} = −50 V, I_B = 0
I_{CBO}	Collector Cutoff Current		1.0		1.0			mA	V_{CB} = −60 V, I_E = 0
							1.0	mA	V_{CB} = −80 V, I_E = 0
								mA	V_{CB} = −100 V, I_E = 0
I_{EBO}	Emitter Cutoff Current		2.0		2.0		2.0	mA	V_{EB} = −5.0 V, I_C = 0
ON CHARACTERISTICS									
h_{FE}	DC Current Gain (Note 1)	1k 500		1k 500		1k 500			I_C = 1.0 A, V_{CE} = −4.0 V I_C = 2.0 A, V_{CE} = −4.0 V
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage (Note 1)		−2.5		−2.5		−2.5	V	I_C = 2.0 A, I_B = 8.0 mA
$V_{BE(on)}$	Base-Emitter "On" Voltage (Note 1)		−2.8		−2.8		−2.8	V	I_C = 2.0 A, V_{CE} = −4.0 V

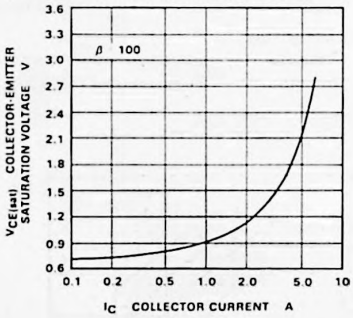
NOTE 1. Pulse conditions: Length = 300 μs, Duty Cycle = 2%.

TYPICAL ELECTRICAL CHARACTERISTICS

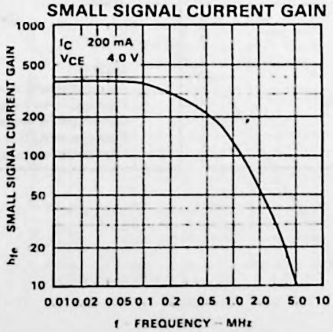
DC CURRENT GAIN



COLLECTOR-EMITTER SATURATION VOLTAGE



SMALL SIGNAL CURRENT GAIN



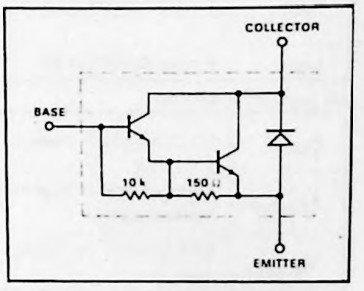
POWER DARLINGTON

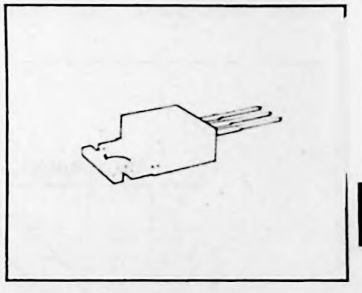
NPN SILICON

TIP120
TIP121
TIP122

GENERAL PURPOSE DARLINGTON SUITABLE FOR HAMMER DRIVERS AND VOLTAGE REGULATORS

- 65 W DISSIPATION AT 25°C CASE
- 5.0 A MAXIMUM CONTINUOUS COLLECTOR CURRENT
- h_{FE} TYPICAL OF 4500 AT 4.0 A
- COMPLEMENTS TO TIP125, TIP126, TIP127





ABSOLUTE MAXIMUM RATINGS

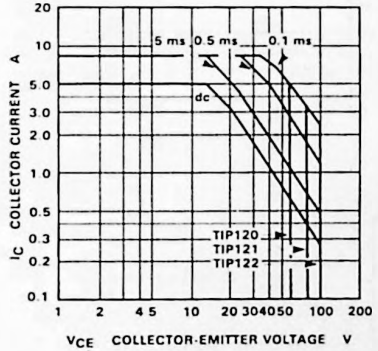
Maximum Voltages and Currents		TIP120	TIP121	TIP122
V_{CE}	Collector to Emitter Voltage	60 V	80 V	100 V
V_{CB}	Collector to Base Voltage	60 V	80 V	100 V
V_{EB}	Emitter to Base Voltage	5.0 V	5.0 V	5.0 V
I_C	Continuous Collector Current	5.0 A	5.0 A	5.0 A
I_C	Peak Collector Current	8.0 A	8.0 A	8.0 A
I_B	Continuous Base Current	0.1 A	0.1 A	0.1 A

Maximum Power Dissipation		
P_D	Total Dissipation @ 25°C Case Temperature	65 W
	Derate Linearly from 25°C	0.52 W/°C

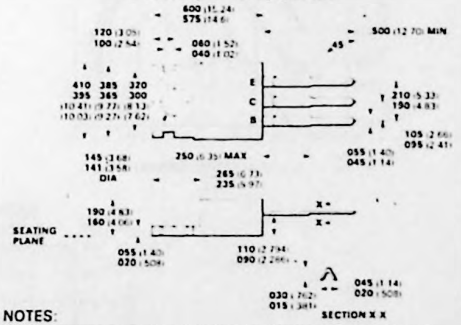
Maximum Temperatures		
T_J, T_{stg}	Storage and Operation Junction Temperatures	−65°C to +150°C

Thermal Characteristics		
$R_{\theta JC}$	Thermal Resistance, Junction to Case	1.92 °C/W
T_P	Maximum Pin Temperature (Soldering, 5 s)	260°C

SAFE OPERATING AREA



JEDEC (TO-220) Outline*



NOTES:
All dimensions in inches (bold) and millimeters (parentheses)
Package is silicone plastic with nickel-plated copper tab and pins
Center pin is electrical contact with the mounting tab
Package weight is 2.1 grams
*Available in various pin configurations

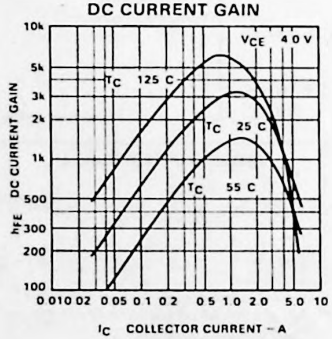
ELECTRICAL CHARACTERISTICS (25°C Case Temperature unless otherwise noted)

SYMBOL	CHARACTERISTIC	TIP120		TIP121		TIP122		UNITS	TEST CONDITIONS
		MIN	MAX	MIN	MAX	MIN	MAX		
OFF CHARACTERISTICS									
$V_{CEO(sus)}$	Collector-Emitter Sustaining Voltage (Note 1)	60		80		100		V	I_C = 30 mA, I_B = 0
I_{CEO}	Collector Cutoff Current		0.5		0.5			mA	V_{CE} = 30 V, I_B = 0
								mA	V_{CE} = 40 V, I_B = 0
							0.5	mA	V_{CE} = 50 V, I_B = 0
I_{CBO}	Collector Cutoff Current		0.2					mA	V_{CB} = 60 V, I_E = 0
					0.2			mA	V_{CB} = 80 V, I_E = 0
							0.2	mA	V_{CB} = 100 V, I_E = 0
I_{EBO}	Emitter Cutoff Current		2.0		2.0		2.0	mA	V_{EB} = 5.0 V, I_C = 0
ON CHARACTERISTICS									
h_{FE}	DC Current Gain (Note 1)	1k		1k		1k			I_C = 0.5 A, V_{CE} = 3.0 V
		1k		1k		1k			I_C = 3.0 A, V_{CE} = 3.0 V
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage (Note 1)		2.0		2.0		2.0	V	I_C = 3.0 A, I_B = 12 mA
			4.0		4.0		4.0	V	I_C = 5.0 A, I_B = 20 mA
$V_{BE(on)}$	Base-Emitter "On" Voltage (Note 1)		2.5		2.5		2.5	V	I_C = 3.0 A, V_{CE} = 3.0 V

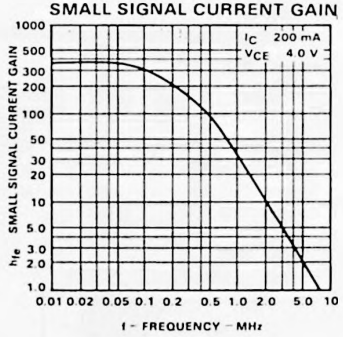
NOTE 1 Pulse conditions Length 300 μs, Duty Cycle 2%

TYPICAL ELECTRICAL CHARACTERISTICS

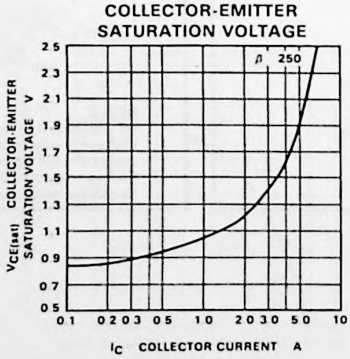
DC CURRENT GAIN



SMALL SIGNAL CURRENT GAIN



COLLECTOR-EMITTER SATURATION VOLTAGE



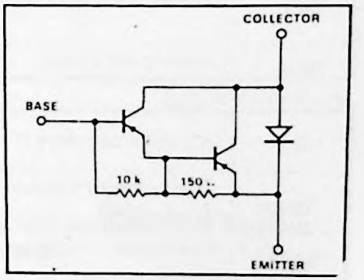
POWER DARLINGTON

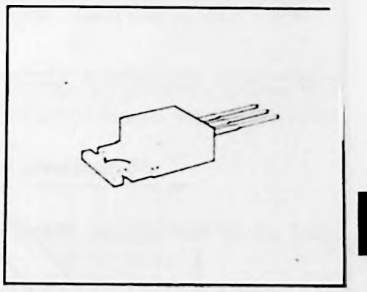
PNP SILICON

TIP 125
TIP 126
TIP 127

GENERAL PURPOSE DARLINGTON SUITABLE FOR HAMMER DRIVERS AND VOLTAGE REGULATORS

- 65 W DISSIPATION AT 25°C CASE
- 5.0 A MAXIMUM CONTINUOUS COLLECTOR CURRENT
- h_{FE} TYPICAL OF 2000 AT 3.0 A
- COMPLEMENTS TO TIP120, TIP121, TIP122





ABSOLUTE MAXIMUM RATINGS

Maximum Voltages and Currents		TIP125	TIP126	TIP127
V_{CE}	Collector to Emitter Voltage	−60 V	−80 V	−100 V
V_{CB}	Collector to Base Voltage	−60 V	−80 V	−100 V
V_{EB}	Emitter to Base Voltage	−5.0 V	−5.0 V	−5.0 V
I_C	Continuous Collector Current	5.0 A	5.0 A	5.0 A
I_C	Peak Collector Current	8.0 A	8.0 A	8.0 A
I_B	Continuous Base Current	0.1 A	0.1 A	0.1 A

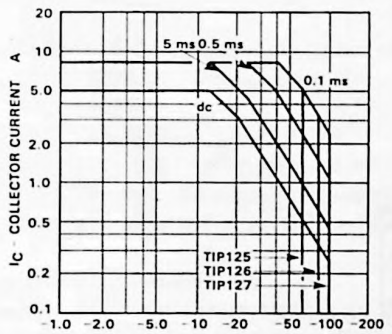
Maximum Power Dissipation		
P_D	Total Dissipation @ 25°C Case Temperature	65 W
	Derate Linearly from 25°C	0.52 W/°C

Maximum Temperatures		
T_J, T_{stg}	Storage and Operation Junction Temperatures	−65°C to +150°C

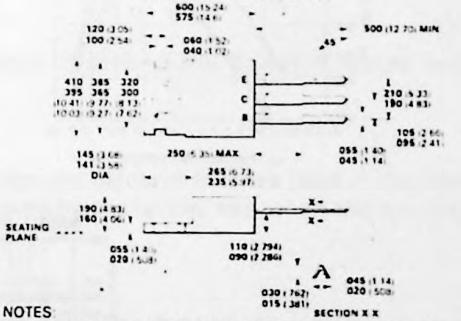
Thermal Characteristics		
$R_{\theta JC}$	Thermal Resistance, Junction to Case	1.92 °C/W
T_P	Maximum Pin Temperature (Soldering, 5 s)	260°C

6

SAFE OPERATING AREA



JEDEC (TO-220) Outline*



NOTES:
All dimensions in inches (bold) and millimeters (parentheses)
Package is silicone plastic with nickel-plated copper tab and pins
Center pin is electrical contact with the mounting tab
Package weight is 2.1 grams
*Available in various pin configurations

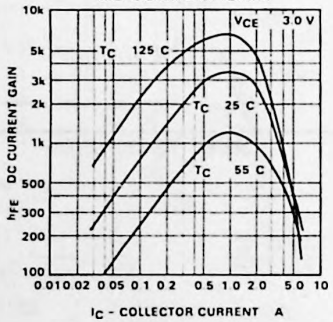
ELECTRICAL CHARACTERISTICS (25°C Case Temperature unless otherwise noted)

SYMBOL	CHARACTERISTICS	TIP125		TIP126		TIP127		UNITS	TEST CONDITIONS
		MIN	MAX	MIN	MAX	MIN	MAX		
OFF CHARACTERISTICS									
$V_{CEO(sus)}$	Collector-Emitter Sustaining Voltage (Note 1)	−60		−80		−100		V	I_C = 30 mA, I_B = 0
I_{CEO}	Collector Cutoff Current		0.5		0.5			mA	V_{CE} = −30 V, I_B = 0
								mA	V_{CE} = −40 V, I_B = 0
							0.5	mA	V_{CE} = −50 V, I_B = 0
I_{CBO}	Collector Cutoff Current		0.2		0.2			mA	V_{CB} = −60 V, I_E = 0
								mA	V_{CB} = −80 V, I_E = 0
							0.2	mA	V_{CB} = −100 V, I_E = 0
I_{EBO}	Emitter Cutoff Current		2.0		2.0		2.0	mA	V_{EB} = −5.0 V, I_C = 0
ON CHARACTERISTICS									
h_{FE}	DC Current Gain (Note 1)	1k		1k		1k			I_C = 0.5 A, V_{CE} = −3.0 V
		1k		1k		1k			I_C = 3.0 A, V_{CE} = −3.0 V
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage (Note 1)		−2.0		−2.0		−2.0	V	I_C = 3.0 A, I_B = 12 mA
			−4.0		−4.0		−4.0	V	I_C = 5.0 A, I_B = 20 mA
$V_{BE(on)}$	Base-Emitter "On" Voltage (Note 1)		−2.5		−2.5		−2.5	V	I_C = 3.0 A, V_{CE} = −3.0 V

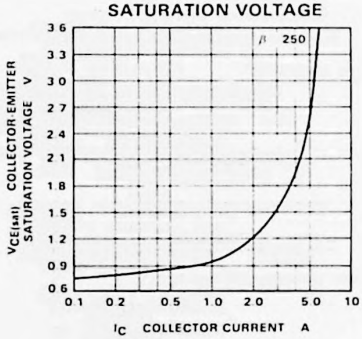
NOTE 1 Pulse conditions: Length 300 μs, Duty Cycle 2%

TYPICAL ELECTRICAL CHARACTERISTICS

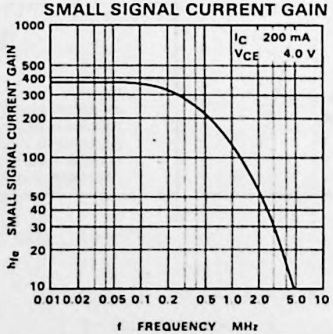
DC CURRENT GAIN



COLLECTOR-EMITTER SATURATION VOLTAGE



SMALL SIGNAL CURRENT GAIN



POWER TRANSISTOR UNENCAPSULATED CHIPS

GENERAL INFORMATION:
The Fairchild power transistor chips described are processed in either Planar or Mesa technology.
Planar Power Transistor Chips Have the Following Characteristics.

- Epitaxial collector for high voltage
- Diffused base and emitter
- Fully passivated junctions for low leakage
- 2.5μ thick aluminum metalization on topside for high current handling and excellent wire bonding.
- 0.8μ thick gold metalization on topside for excellent eutectic die attach.
- Chip thickness of 175μ ± 15μ

Mesa Power Transistor Chips Have the Following Characteristics.

- Epitaxial collector for high voltage
- Epitaxial base for high voltage and power capability
- Diffused emitter
- 5μ thick aluminum metalization on topside for high current handling and excellent wire bonding.
- 0.8μ chrome-silver metalization on backside for good soft solder die attach.
- Chip thickness of 200μ ± 15μ

VISUAL INSPECTION
Fairchild power transistor dice go through extensive visual inspection during die processing (see flow chart). Die are visualed at 40X to 100X magnification using Fairchild's standard visual inspection criteria. Copies of the visual inspection documents are available upon request.

OPTIONS
All power transistor dice can be procured in either of the two following forms. Cavity Pack is our standard method of packaging, but, the other option is available.

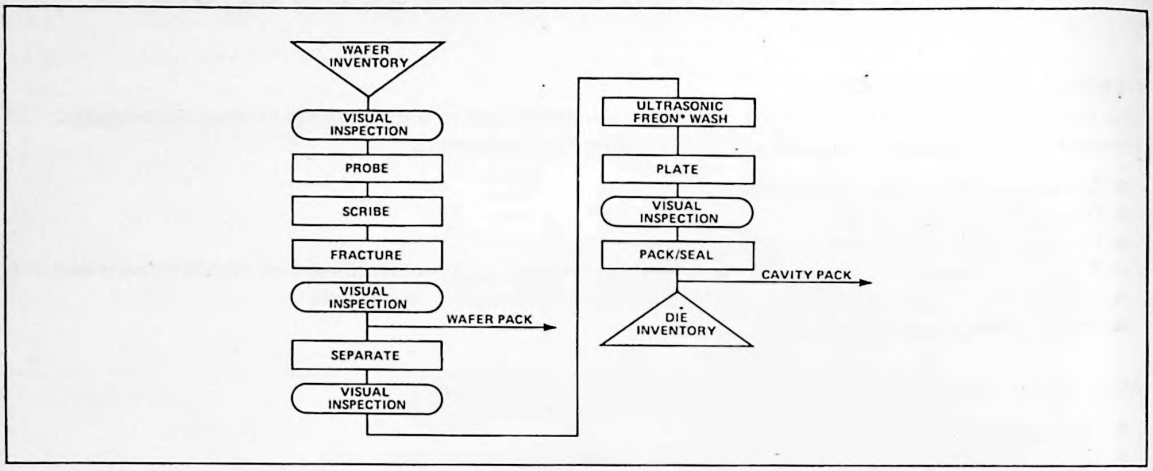
Cavity Pack - wafers are 100% tested, reject dice are inked and removed. Good dice are cleaned, visualed, and shipped in individual cavities (see *Figure 1*).

Wafer Pack - wafer is tested, reject dice are inked, wafer is scribed and fractured. Entire wafer is shipped in wafer form (see *Figure 2*).

STANDARD DICE SPECIFICATIONS
Power transistor dice are assigned an SP number. The dice are identical to those used in the Fairchild assembled devices. Customer requirements will be reviewed by the factory and when the specification is negotiated satisfactorily an SP number will be assigned.

PARAMETER GUARANTEES
Probing in die form limits testing to 25°C dc parameters only. The factory will correlate tests to be probed to customer requirements. These probed dc tests are guaranteed to an LTPD of 10%.
The ac parameters which will be similar to those on Fairchild data sheets, will be correlated to selected dc parameters and are guaranteed to an LTPD of 20%.

STANDARD DICE PROCESSING
The power transistor dice listed are produced on the same well-proven production lines that produce Fairchild's standard encapsulated devices.
The following flow chart will show the additional steps that are done once a wafer is selected for processing in die form.



ORDERING INFORMATION

When ordering be sure to call out the SP number, not the 2N number. Just specify the device type, quantity and the packaging method preferred.

HANDLING PRECAUTIONS

Extreme care must be used in handling unencapsulated semiconductors to avoid damage to the chip surface. The following precautions apply.

Wafer Pack - Wafers should only be handled near the edge with round ended stainless steel or teflon tweezers.

Cavity Pack - Lid and anti-static mylar should be removed slowly and with extreme care to avoid disturbing position of the dice. Dice should be handled with a smooth tipped vacuum wand only. Do not use tweezers.

In addition, devices should be stored in an environment of not more than 30% relative humidity. Die and wire bonding should not exceed 400°C in an inert atmosphere or 100°C in a non-inert atmosphere.

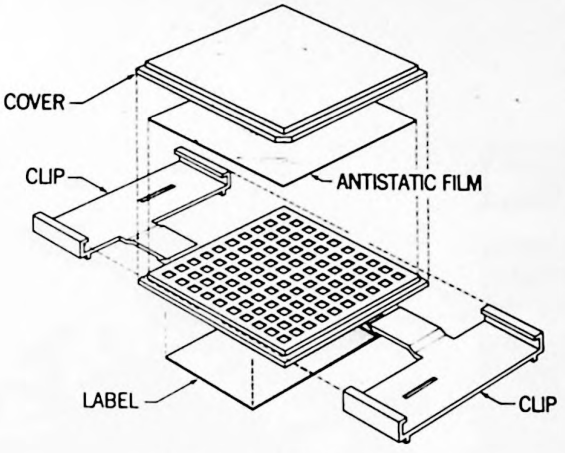


Fig. 1 CAVITY PACK

Fig. 1
CAVITY PACK – Dice are Placed in Individual Compartments. The Plastic Snap Clips Permit Inspection and Resealing.

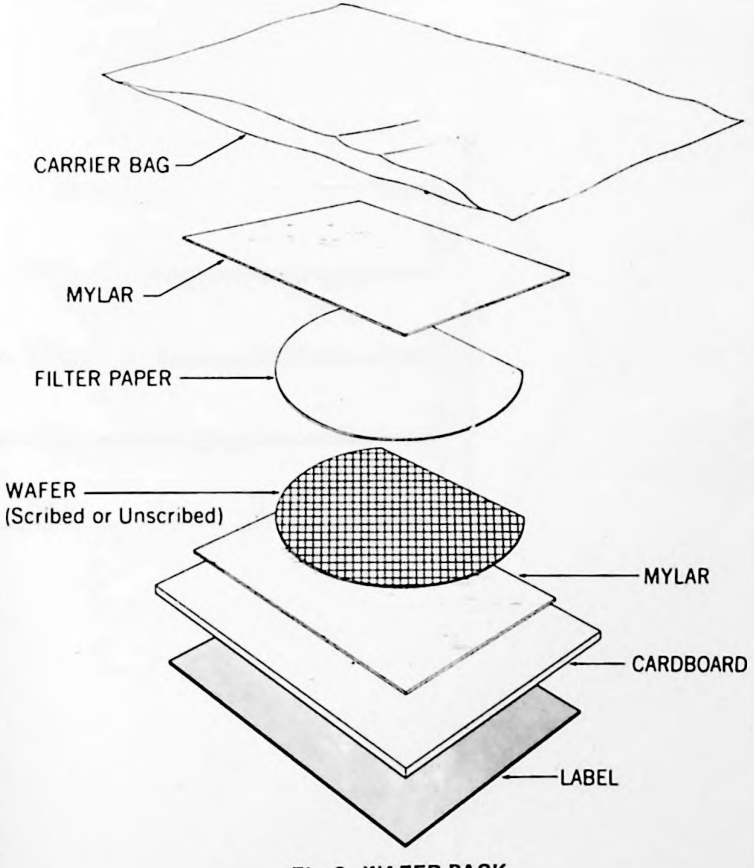
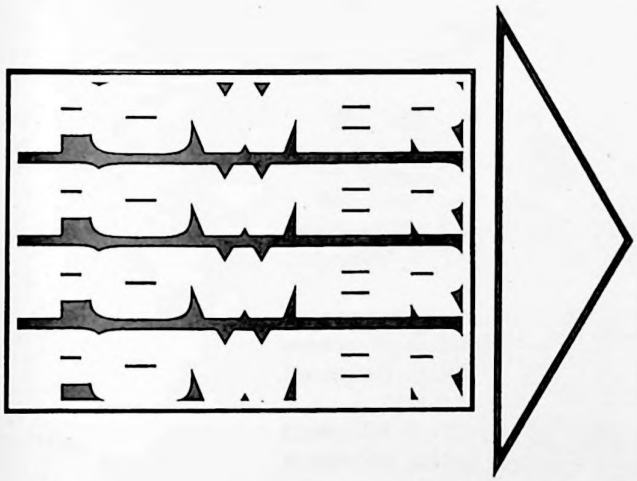


Fig. 2 WAFER PACK

Fig. 2
WAFER PACK – Entire Wafer is Sandwiched Between Two Pieces of Mylar and Vacuum Sealed in a Plastic Envelope.



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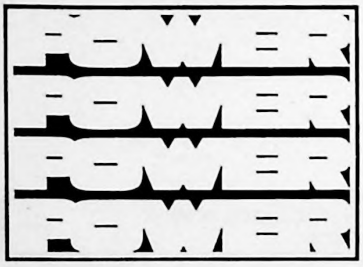
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POWER TRANSISTOR SYMBOLS, TERMS AND DEFINITIONS

Base (B,b)*	A region which lies between an emitter and collector of a transistor and into which minority carriers are injected.
Breakdown	A phenomenon occuring in a reverse-biased semiconductor junction, the initiation of which is observed as a transition from a region of high small-signal resistance to a region of substantially lower small-signal resistance for an increasing magnitude of reverse current.
Breakdown Region	A region of the volt-ampere characteristic beyond the initiation of breakdown for an increasing magnitude of reverse current.
Breakdown Voltage	The voltage measured at a specified current in a breakdown region.
BV_{CBO}	*Collector-Base Breakdown Voltage:* The breakdown voltage of the collector base junction when reverse biased with the emitter terminal open.
BV_{CEO}	*Collector-Emitter Breakdown Voltage:* The collector-to-emitter breakdown voltage with the base terminal open circuited.
BV_{CER}	*Collector-Emitter Breakdown Voltage:* The collector-to-emitter breakdowr voltage with the base connected to the emitter through a resistor.
BV_{CES}	*Collector-Emitter Breakdown Voltage:* The breakdown voltage of the transistor when the collector is reverse biased with respect to the emitter and the base is terminated through a short circuit to the emitter.
C_{cb}	*Interterminal Capacitance (Collector-to-Base):* The direct interterminal capacitance between the collector and base with the collector-base junction reverse biased and the emitter terminal open circuited to dc, but ac connected to the guard terminal of a 3-terminal bridge. This capacitance includes the interelement capacitance plus capacitance to the shield where the shield is connected to one of the terminals under measurement.
C_{eb}	*Interterminal Capacitance (Emitter to Base):* Capacitance measured with the emitter base reverse biased, the collector open circuited but ac connected to the guard circuit.
C_{ibo}	*Open-Circuit Input Capacitance (Common-Base):* The capacitance measured across the emitter and base terminals with the collector open circuited for ac.
C_{obo}	*Open-Circuit Output Capacitance (Common-Base):* The capacitance measured across the collector and base terminals with the emitter open circuited to ac.
Collector(C,c)*	A region through which a primary flow of charge carriers leaves the base.
C_{rb}	*Reverse Transfer Capacitance:* in common-base configuration.
C_{re}	*Reverse Transfer Capacitance:* in common-emitter configuration.
Emitter(E,e)*	A region from which charge carriers that are minority carriers in the base are injected into the base.

*Note: References to base, collector, and emitter symbolism (B, b, C, c, E, and e) refer to the device terminals connected to those regions.

f	*Frequency.*
f_c	*Cut-off frequency.*
f_{hfe}	*Small-Signal Short-Circuit Forward-Current Transfer-Ratio Cutoff Frequency (Common-Emitter):* The lowest frequency at which the magnitude of the small-signal short-circuit forward-current transfer ratio is 0.707 of its value at a specified low frequency (usually 1 kHz or less).
f_T	*Current-Gain-Bandwidth Product:* Frequency at which small-signal forward-current transfer ratio (common-emitter) extrapolates to unity. The product of the modulus (magnitude) of the common-emitter small-signal short-circuit forward current transfer ratio, h_{fe}, and the frequency of measurement when this frequency is sufficiently high so that the modulus of the h_{fe} is decreasing with a slope of approximately 6 dB per octave.
G_{PE}	*Large-Signal Insertion Power Gain (Common-Emitter):* The ratio, usually expressed in dB, of the signal power delivered to the input.
h_{FE}	*DC Current Gain:* The ratio of collector current (I_C) to the base current (I_B) at a specified collector-emitter voltage.
h_{fe}	*Small-Signal Short-Circuit Forward-Current Transfer Ratio (Common-Emitter):* The ratio of the ac output current to the small-signal ac input current with the output short circuited to ac. This small signal-current gain is measured at a relatively low frequency, usually 1 kHz.
$\lvert h_{fe} \rvert$	*Small-Signal Short-Circuit Forward-Current Transfer Ratio (Common-Emitter):* The ratio of the ac output current to the small-signal ac input current with the output short circuited to ac.
h_{IE}	*Static Input Resistance (Common-Emitter):* The ratio of the dc base-emitter voltage to the dc base current.
h_{ie}	*Small-Signal Short-Circuit Input Impedance (Common-Emitter):* The ratio of the small-signal ac base-emitter voltage to the ac base current with the collector short circuited to the emitter for ac.
$h_{ie\ (imag)}$	*Imaginary Part of the Small-Signal Short-Circuit Input Impedance, (Common-Emitter):* The ratio of the out-of-phase (imaginary) component of the small-signal ac base-emitter voltage to the ac base current with the collector terminal short circuited to the emitter terminal for ac.
$h_{ie\ (real)}$	*Real Part of the Small-Signal Short-Circuit Input Impedance, (Common-Emitter):* The ratio of the in-phase (real) component of the small-signal ac base-emitter voltage to the ac base current with the collector terminal short circuited to the emitter terminal for ac.
h_{oe}	*Small-Signal Open-Circuit Output Admittance, (Common-Emitter):* The ratio of the ac collector current to the small-signal ac collector-emitter voltage with the base terminal open circuited to ac.

h_{oe} (imag) — *Imaginary Part of the Small-Signal Open-Circuit Output Admittance, (Common-Emitter):* The ratio of the ac collector current to the out-of-phase (imaginary) component of the small-signal collector-emitter voltage with the base terminal open circuited to ac.

h_{oe} (real) — *Real Part of the Small-Signal Open-Circuit Output Admittance, Common-Emitter):* The ratio of the ac collector current to the in-phase (real) component of the small-signal collector-emitter voltage with the base terminal open circuited to the ac.

I_B — *Base Current (Continuous):* The maximum base current which the transistor can handle without failure.

I_B (Peak) — *Base Current (Peak):* The peak base current which the transistor can handle without catastrophic failure. Time must be considered.

I_C — *Collector Current (Continuous):* The maximum dc collector current which the transistor can handle on a continuous basis without failure.

I_C (peak) — *Collector Current (Peak):* The peak collector current which the transistor can handle without catastrophic failure. Time must be considered.

I_E — *Emitter Current (Continuous):* The maximum continuous emitter current which the transistor can carry without failure.

I_{CBO} — *Collector Cutoff Current:* Collector current measured with the collector-base junction reverse biased and the emitter terminal open.

I_{CEO} — *Collector Cutoff Current:* Collector-emitter current measured with the base terminal open.

I_{CER} — *Collector Cutoff Current:* Collector current measured with the collector-base junction reverse biased and the base terminal connected to the emitter through a resistor.

I_{CES} — *Collector Cutoff Current:* Collector current measured with the collector reverse biased with respect to the emitter and the base terminal shorted to the emitter.

I_{CEV} — *Collector Cutoff Current:* The dc current into the collector terminal when it is biased to the reverse direction with respect to the emitter terminal and the base terminal is returned to the emitter terminal through a specified voltage.

I_{CEX} — *Collector Cutoff Current:* Collector current measured with the collector reverse biased with respect to the emitter and the base terminated with a specified circuit between base and emitter.

I_{EBO} — *Emitter Cutoff Current:* The emitter current as measured when the emitter-base junction is reverse biased and the collector terminal is open.

Junction, Collector — A semiconductor junction normally biased in the high-resistance direction, the current through which can be controlled by the introduction of minority carriers into the base.

Junction, Emitter	A semiconductor junction normally biased in the low-resistance direction to inject minority carriers into the base.
Open Circuit	A circuit shall be considered as open circuited if halving the magnitude of the terminating impedance does not produce a change in the parameter being measured greater than the required accuracy of the measurement.
P_D	*Total Device Power Dissipation:* The maximum power which the device can dissipate reliably at the specified case temperature. Case temperature must be controlled and second-breakdown limitations observed.
P_{out}	*Output Power.*
R	*Resistance.*
rb'Cc	*Collector-Base Time Constant:* The product of the intrinsic base resistance and collector capacitance under specified small-signal conditions.
R_{BE}	*Base-Emitter Resistance.*
Reverse Current	The current that flows through a semiconductor junction in the reverse direction.
Reverse Direction	The direction of current flow which results when the n-type semiconductor region is at a positive potential relative to the p-type region.
$R\theta_{JA}$	*Thermal Resistance, Junction-To-Ambient:* The thermal resistance (resistance to heat flow) from the junction of the transistor to the ambient.
$R\theta_{CS}$	*Thermal Resistance, Case-To-Heat-Sink:* The thermal resistance from the case of the transistor to its mounting surface.
Safe Operating Area	A defined region of operation which will ensure reliable operation of the transistor. Limits upon current as a function of voltage and time as shown.
Saturation	A base-current and a collector-current condition resulting in a forward-biased collector junction.
Second Breakdown	A condition of the transistor, resulting from a lateral current instability, in which the electrical characteristics are determined principally by the spreading resistance of a thermally maintained current constriction. The initiation of second breakdown is observed as a decrease in the voltage sustained by the collector.
Semiconductor Device	A device whose essential characteristics are due to the flow of charge carriers within a semiconductor.
Semiconductor Junction.	A region of transition between semiconductor regions of different electrical properties (e.g., n-n+, p-n, p-p+ semiconductors), or between a metal and a semiconductor.
Short Circuit	A circuit in which doubling the magnitude of the terminating impedance does not produce a change in the parameter being measured that is greater than the required accuracy of the measurement.

Small Signal

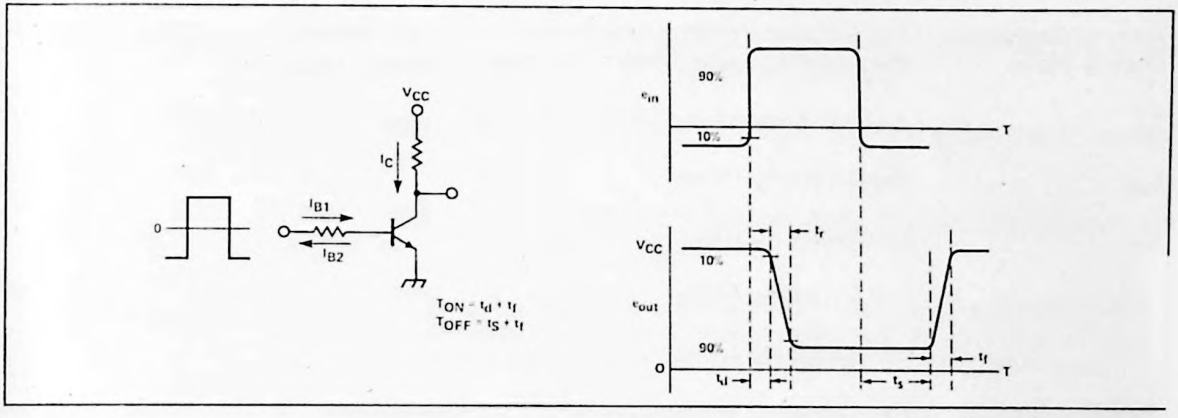
A signal which when doubled in magnitude does not produce a change in the parameter being measured that is greater than the required accuracy of the measurement.

Static Value

A non-varying value or quantity of measurement at a specified fixed point, or the slope of the line from the origin to the operating point on the appropriate characteristic curve.

Switching Times

Common-emitter switching parameters consist of t_d, t_r, t_s and t_f. In the following circuit, drive-circuit conditions and collector-circuit conditions must be specified. The transition times of the input must be negligible compared to the measured times.



t_d — *Delay Time:* The time interval during turn-on from the point when the input pulse at the base reaches 10% of its full amplitude to the point when the collector pulse changes from 0 to 10% of its maximum amplitude.

t_r — *Rise Time:* The time interval during turn-on in which the collector pulse changes from 10% to 90% of its maximum amplitude.

t_s — *Storage Time:* The time interval during turn-off from the point when the turn-off pulse at the base changes from 100% to 90% of its full amplitude to the time when the collector current has changed from 100% to 90% of its maximum amplitude.

t_f — *Fall Time:* The time interval during turn-off in which the collector pulse decreases from 90% to 10% of its maximum amplitude.

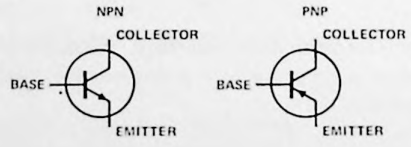
t_{off} — *Turn-Off Time:* The sum of $t_s + t_f$

t_{on} — *Turn-On Time:* The sum of $t_d + t_r$

t_p — *Pulse Time:* The time duration from the point on the leading edge which is 50% of the maximum amplitude to a point on the trailing egde which is 50% of the maximum amplitude.

t_w — *Pulse Average Time:* The time duration from the point on the leading edge which is 50% of the maximum amplitude to a point on the trailing edge which is 50% of the maximum amplitude.

T_A	*Ambient Temperature or Free Air Temperature:* The air temperature measured below a device, in an environment of substantially uniform temperature cooled only by natural air convection and not materially affected by reflective and radiant surfaces.
T_C	*Case Temperature:* The temperature of the transistor package or case, measured at a specific point.
t_d	*See Switching Times.*
Terminal	An externally available point of connection to one or more electrodes.
t_f	*See Switching Times.*
Thermal Resistance (Steady State)	The temperature difference between two specified points or regions divided by the power dissipation under conditions of thermal equilibrium.
T_J	*Junction Temperature:* The junction temperature of the transistor.
t_{off}	*See Switching Times.*
t_{on}	*See Switching Times.*
t_p	*See Switching Times.*
t_r	*See Switching Times.*
Transient Thermal Impediance	The change of temperature difference between two specified points or regions at the end of a time interval divided by the step-function change in power dissipation at the beginning of the same time interval causing the change of temperature difference.
Transistor	An active semiconductor device capable of providing power amplification and having three or more terminals.
Transistor, Junction, Multijunction Type	A transistor having a base and two or more junctions. Below are the graphic symbols for emitter, base, collector transistors. In the graphic symbols, the envelope is optional if no element is connected to the envelope.
T_{stg}	*Storage Temperature:* The minimum and maximum storage temperature under which the device can be safely stored without causing damage.



t_w	*See Switching Times.*
V_{BB}	*Supply Voltage, dc (Base):* The dc supply voltage applied to a circuit connected to the base.
V_{BE}	*Base-Emitter Voltage:* The base-emitter voltage as measured with the collector current and collector-emitter voltage specified.
$V_{BE\ (sat)}$	*Base-Emitter Saturation Voltage:* The base-emitter voltage as measured with conditions as specified for $V_{CE(sat)}$.
V_{CB}	*Collector-Base Voltage:* The maximum voltage which may be applied across the collector-base terminals with base termination specified.
V_{CBO}	*Collector-Base Voltage:* The maximum voltage which may be applied to the collector-base terminals with the emitter terminal open.
V_{CC}	*Supply Voltage DC, (Collector):* The dc supply voltage applied to a circuit connected to the collector.
V_{CEO}	*Collector-Emitter Voltage:* The maximum voltage which may be applied to th collector-emitter terminals with the base terminal open.
$V_{CEO(sus)}$	*Collector-Emitter Sustaining Voltage:* Collector-to-emitter breakdown voltag with the base terminal open. The voltage specified is at the lowest portion of any negative resistance region on the voltage-breakdown characteristic curve.
V_{CER}	*Collector-Emitter Voltage:* The maximum voltage which may be applied between the collector and the emitter with the base terminal connected through a resistor to the emitter.
$V_{CER(sus)}$	*Collector-Emitter Sustaining Voltage:* The collector-emitter voltage obtained by reverse-biasing the collector with respect to the emitter and the base terminated through a resistor to the emitter. Test current must be the proper magnitude so that the voltage measured is at the lowest point of any negative resistance region on the characteristic breakdown curve.
V_{CES}	*Collector-Emitter Voltage:* The maximum voltage which may be applied between the collector and emitter with the base terminal shorted to the emitter terminal.
$V_{CE(sat)}$	*Collector-Emitter Saturation Voltage:* The dc voltage measured between the collector-emitter terminals at specified current conditions.
V_{EBO}	*Emitter-Base Voltage:* The maximum voltage which may be applied to the emitter-base terminals with the collector terminal open.
V_{EC}	*Emitter-to Collector dc Voltage.*
η	*Efficiency.*

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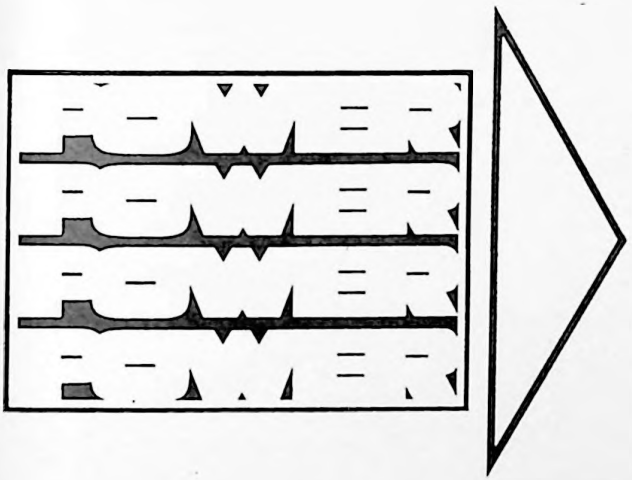

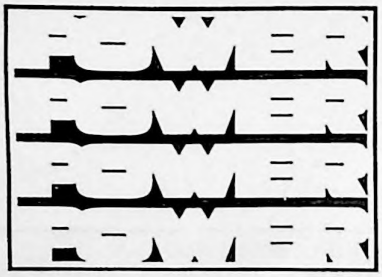
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***LOS ANGELES, CALIFORNIA**
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Suite 818
Tel. 213-466-8393 TWX 910-321-3009

***SAN DIEGO, CALIFORNIA**
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Tel. 714-279-6021

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